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O C Marsh

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

OTHNIEL CHARLES MARSH.

Among the leading men of science in America, Professor Marsh was unquestionably one of the best known, and had one of the strongest personalities. The world-wide reputation he enjoyed, however, is not altogether attributable to the particular department of research in which he stood without a peer, for, added to his attainments in Vertebrate Paleontology, he possessed an unusual number of mental qualifications in other lines, as well as marked personal characteristics which made him known and felt where his science could never reach. His fame will undoubtedly rest on his work among the Fossil Vertebrates. Nevertheless, his energy and attainments in other directions were sufficient to have made for him a permanent record.

The nearness of the perspective at the present time renders it difficult properly to individualize and accord the true rank to the many important discoveries Marsh has made. He brought forth in such rapid succession so many astonishing things that the unexpected became the rule. The science of Vertebrate Paleontology could not assimilate new material so fast, and it will be years before the true significance and bearing of much that he has done will be understood. The constant stream of vertebrate riches which, from 1868 to 1899, flowed into the Yale University Museum from the Rocky Mountain region had a similar bewildering effect on Marsh, for

it was impossible for him to do more than seize on what appealed to him as the most salient. The work of the hour was to him of prime importance, whether it was for the determination of a new order of mammals or a new cusp on a tooth. Still, he seems to have had a just conception of relative values, for it will be found that he plucked the most luscious plums from the paleontological tree, and left chiefly the smaller or unripe and imperfect fruit untouched.

Another element in his success was seen in the improvement he made in the methods of collecting, preserving, and developing vertebrate fossils, so that even forms long known only from fragmentary remains were represented in his collections by almost complete specimens, presenting nearly the same degree of novelty shown in forms actually new.

In illustration of this, the Brontotheridæ, Ceratopsia, and the Mosasauria furnish excellent examples. Prout, in 1846, described, as *Palæotherium*, the fragment of a lower jaw from the Miocene of Nebraska, but Marsh first showed the affinities and range of forms in the group, through his splendid restoration of *Brontops* and the description of a number of allied types from nearly perfect material. Cope, in 1875, figured some pieces of bone of unknown relationships, which long remained in the paleontological scrap-basket.* Marsh, by his descriptions of the marvelous series of genera and species belonging to the Ceratopsia, demonstrated what these reptiles really were, and gave to science a nearly complete knowledge of one of the most bizarre monsters known. The first Mosasaur was obtained in Holland previous to 1785. It remained imperfectly known for nearly a century, when Marsh, by his contributions to its anatomy, made possible a clear understanding of its structure and affinities. In the same way it could be shown that to many old descriptions of genera and species based upon single teeth, he was enabled to add a knowledge of the remainder of the animal. Not only did he thus contribute the missing information in regard to many previously described forms, but he brought out a host of entirely new types, and made his science one of the most complete exponents of the doctrine of evolution.

* *Polyonax.*

As a collector, Marsh was seen at his best, and the collections he amassed during his forty-five years and more of activity in this direction form a lasting monument to his perseverance and foresight. A person with means and inclination may be supposed to have the necessary qualities for accomplishing his aims, whether they are first editions, autographs, or fossils, but had Marsh possessed no further qualifications than these, the results of his collecting would fall far short of what he really attained. He not only had the means and the inclination, but entered every field of acquisition with the dominating ambition to obtain everything there was in it, and leave not a single scrap behind. Every avenue of approach was made use of, and cost was often a secondary consideration. The nine-tenths, when attained, were only an additional stimulus for securing the remaining one-tenth. Of course, this ideal of completeness was often impossible of accomplishment, and yet it served to bring to the Yale University Museum collections which are unique from their richness and extent.

In making an estimate of his character, it must not be forgotten that he developed wholly without the influence of family and home ties, which in most men profoundly mark their mature life. Self-reliance is probably the strongest trait fostered by the absence of immediate family connections. This, Marsh possessed to an extraordinary degree, and it naturally led to a self-centering of his life and ambitions. Out of it came, also, an absence of the complete exchange of confidence which normally exists between intimate friends. Even where perfect confidence existed, he seldom revealed more about any particular matter than seemed to him necessary or than the circumstances really demanded. As a friend, he was kind, loyal, and generous. As a patron of science, he has seldom been equaled. Honest work in any department appealed to him strongly, and he was ever ready with aid and counsel, even at the expense of a personal sacrifice. His disposition was a most happy one, and he was always keenly appreciative of the humorous and ludicrous and fond of relating amusing experiences and anecdotes. The sunny side of his

character was nearly always uppermost, and the consideration of subjects of the greatest gravity was enlivened by constant sparkles of wit from his exhaustless store.

He was normally restive under restraint, and met all opposition with power and fearlessness. Having practically created the modern science of Vertebrate Paleontology in America, he resented any encroachment upon the particular fields of research in which he was engaged. This attitude frequently developed feelings of hostility in other investigators, and often alienated him from co-workers in his department of science. Nevertheless, he labored faithfully for the truth as revealed in his work, and was ready to change opinions and published statements whenever facts seemed to warrant it.

His esthetic sense was highly developed, and could be seen in the artistic care he bestowed upon his publications, but more especially on his home. His grounds are a model of landscape gardening. He delighted in his collections of modern paintings, the cultivation of orchids, and above all in the subtleties of Japanese art.

The world was not slow to recognize his contributions to knowledge, for during his lifetime he received a large number of tangible evidences of distinguished consideration in the way of academic and scientific honors, medals, and membership in learned societies.

In 1886, he received the degree of Doctor of Laws from Harvard University, and in the same year the honorary degree of Doctor of Philosophy from the University of Heidelberg. He occupied the chair of Paleontology in Yale University from 1866 to the time of his death. He was Vertebrate Paleontologist to the United States Geological Survey, and Honorary Curator of Vertebrate Paleontology in the United States National Museum.

He was President of the American Association for the Advancement of Science in 1878, and of the National Academy of Sciences from 1883 to 1895. As a presiding officer in the National Academy, he exercised the same amount of care that he bestowed upon his private affairs, and was an active and efficient leader.

In 1877, he was the recipient of the first Bigsby Medal awarded by the Geological Society of London, in recognition of his important labors on the Vertebrate Paleontology of the western territories of the United States. In 1898, the highly valued Cuvier Prize was given him by the French Academy, as one of the most able continuators of the science of which Cuvier had laid the foundations.

Prominent among the various societies of which he was a member may be mentioned:

The National Academy of Sciences; Institute of France; Royal Academy of Sciences, Brussels; Royal Bavarian Academy of Sciences, Munich; Royal Academy of Sciences, Bologna; Royal Danish Academy of Sciences, Copenhagen; Royal Irish Academy; Geological Society of London; Geological Society of Germany; American Philosophical Society; Academy of Natural Sciences, Philadelphia; Zoological Society of London; Société Impériale des Naturalistes, Moscow; Geological Society of America, etc., etc.

Few men have contributed more to THE AMERICAN JOURNAL OF SCIENCE than Professor Marsh. Nearly all his discoveries in science were first announced here, and it is the storehouse of most of his best work.

The subject of the present sketch was born near Lockport, New York, October 29, 1831. His parents were Caleb and Mary Peabody Marsh, formerly of Danvers (now Peabody), Massachusetts. His early education was obtained in the schools of Lockport and at the Wilson Collegiate Institute, Wilson, New York. A residence in a region rich in minerals and fossils is apt to attract the attention of a youth possessing healthy intelligence, and young Marsh soon shared his vacation time between the normal pursuits of shooting and fishing and the more unusual vocation of collecting minerals and fossils. By the time he was nineteen years old, he had thus acquired the taste for scientific subjects which was destined to grow and dominate the remainder of his life.

In 1851, he entered Phillips Academy at Andover, Massachusetts, and continued his studies there until graduation in

1856. He immediately entered the freshman class in Yale College, pursuing the regular classical course, and receiving the degree of B.A. in 1860. Graduate courses in the natural sciences were continued in the Sheffield Scientific School during the two years following (1861–62). The long summer vacations from 1851 to 1862 were occupied in collecting minerals and fossils from New York, New England, and Nova Scotia. To the latter region he made five trips during this interval, and obtained much valuable experience and scientific material. On his second visit (1855) he found some fossil vertebræ in the Coal Measures at South Joggins, representing a new and important vertebrate animal (*Eosaurus*). This discovery finally directed his studies into the channel which became his life-work. At this time, however, his interests were about equally divided between invertebrate paleontology and mineralogy, and it is worthy of note that his first scientific paper was published in THIS JOURNAL in 1861, under the title "The Gold of Nova Scotia."

The description of *Eosaurus* did not appear until 1862, seven years after its discovery. Even then it cannot be said that he had developed a strong liking for vertebrate paleontology. This closes the account of his student life in American schools.

The next three years were passed in study abroad, in the universities of Berlin, Heidelberg, and Breslau. He attended lectures and took special courses with H. Rose, G. Rose, Ehrenberg, Peters, Rœmer, Grube, and Gœppert. The vacations were occupied, as before, by geological excursions. He visited the most important localities in Europe, and obtained extensive collections. His official connection with Yale College began by his appointment, in 1866, to the chair of Professor of Paleontology. This title he held in high esteem, as it was the first established either in this country or elsewhere.

After attending the meeting of the American Association for the Advancement of Science at Chicago, in 1868, Marsh went as far west as Nebraska and Wyoming, along the route of the Union Pacific railroad, then just opened. This trip gave him a foretaste of the inexhaustible fossil riches of the

Rocky Mountain regions, and thenceforth his energies were mainly devoted to their exploration. Scientific expeditions to the western country were undertakings of considerable magnitude in those early days. There was but one railroad in the United States across a region measuring fifteen hundred miles square. White settlements were sparse and remote. Most of the country was unmapped, and with the exception of a few transcontinental trails, almost the whole western half of the continent, save the regions bordering the Pacific, was a boundless expanse of unknown arid plains, mountains, and valleys. Added to these conditions were the indigenous tribes of war-loving Indians, hostile to the whites. Under such circumstances, travel was slow, difficult, and dangerous. It was necessary to have an escort of soldiers and guides, experienced in western life and Indian warfare.

The first Yale Scientific Expedition was organized and engineered by Marsh in 1870. The party consisted of thirteen persons besides the officers and men of the military detachments who escorted them from various military posts along the route.* They explored the Pliocene deposits of Nebraska and the Miocene of northern Colorado, then crossing into Wyoming they made collections in the Eocene (Bridger Basin), and passing south discovered a new Eocene basin in Utah (Uinta Basin). At each of these places many important finds were made. The party next visited California, where minor collections were obtained from the Pliocene. Returning, they

* Members of the Yale party were O. C. Marsh, C. T. Ballard, C. W. Betts, A. H. Ewing, G. B. Grinnell, J. W. Griswold, J. R. Nicholson, C. McC. Reeve, J. M. Russell, H. B. Sargent, J. W. Wadsworth, E. Whitney, Jr., and H. D. Ziegler. The escorts consisted of:—

From Fort McPherson, Nebraska.—Commanding officer, Gen. Eugene A. Carr. Lieuts. Bernard Reilly, Jr., and Earl D. Thomas, in command of escort, 5th Cavalry; Buffalo Bill and Major Frank North, guides; and two Pawnee Indian scouts ("Lahurasoc" and "Tuckatelous").

From Fort D. A. Russell, Wyoming.—Commanding officer, Gen. John H. King. Capt. Robert H. Montgomery and Lieut. James McB. Stembel, in command of escort, 5th Cavalry.

From Fort Bridger, Wyoming.—Commanding officer, Major R. S. LaMotte. Lieut. W. N. Wann, in command of escort, 13th Infantry: Mexican guide ("Joe Talemans").

From Fort Wallace, Kansas.—Commanding officer, Gen. Henry C. Bankhead. Ed. Lane, guide; Lieut. Charles Braden, in command of rescue troop.

spent some time exploring the Cretaceous beds of western Kansas, so rich in the remains of aquatic reptiles, and now famous for having furnished the first toothed birds and American toothless flying reptiles.

The second, third, and fourth Yale Scientific Expeditions (1871, 1872, 1873) were modeled after the first. New regions in the West were visited, and extensive series of remains of extinct animals were obtained. Coincident with these discoveries, Marsh published frequent scientific papers describing and illustrating the more important forms, and paleontological literature was enriched by the addition of more startling and wonderful types of animal life than had been hitherto known from the rest of the world.

Owing to Indian outbreaks and a general uneasiness in the West, no regular expedition was organized in 1875. Late in the fall, however, Marsh went to the Bad Lands of Nebraska and Dakota accompanied by an escort from Fort Laramie to the Red Cloud Agency. The consent of the Indians was deemed necessary to search for fossil bones in their country. A treaty was obtained with difficulty and then assistance was withheld. Nevertheless, with great hardship owing to extreme cold, the party succeeded in reaching the desired region, and made important discoveries, among which numerous remains of the gigantic Brontotheridæ are the most noteworthy.

It was at this time that he became aware of the frauds practiced upon the Indians by the agents of the Government, and the way the Government was in turn defrauded through their misrepresentations. He promised Red Cloud to bring the matter before the President for redress. This was done with signal success, resulting in the complete routing of the Indian Ring, and the downfall of the Secretary of the Interior as well as in his political death.

The rapid settlement and development of the West rendered it no longer necessary to fit out expensive expeditions, especially as many of the localities were easily accessible by railroad. Therefore, after 1876, local collectors and small parties were employed in continuing the work of collecting fossils so successfully begun by the Yale Scientific Expeditions. Nearly every season, however, Marsh visited the localities where work

was being carried on, and some time each year was spent in reconnaissance for new fields of labor.

The right wing of the Peabody Museum was completed in 1875, the means having been furnished by Mr. George Peabody largely through the influence of his nephew, Professor Marsh. It was to his uncle, also, that Marsh was indebted for his educational advantages and for his private fortune. The old Yale Cabinet had long been outgrown. The rooms became so crowded that for years there was only space for a chalk line dividing the different departments. The collections which had been accumulating during so many previous years found a commodious home in the new museum, and work was resumed with great activity under more favorable conditions than heretofore. Huxley's visit in the following year was a further stimulus to higher work, as is clearly evinced in the celebrated Nashville address mentioned elsewhere.

The National Government had not altogether neglected its opportunities for scientific research in the West during this period, though the results in the way of substantial collections were far inferior to those Marsh had obtained. For some time previous to 1878, there were four separate surveys, two under the Engineer Department of the Army and two others, extensions of private expeditions, under the Department of the Interior. In the reorganization ordered by Congress in 1878, Marsh, as acting President of the National Academy of Sciences, was the chief instrument in effecting a consolidation and in defining the relations of the present United States Geological Survey with the general Government and with the United States National Museum. The wisdom of this change was at once apparent, and the Survey is now often considered one of the most economical, best managed, and productive departments of the Government.

After repeated solicitation and with promises of material aid in the way of publication and collections, Marsh, in 1882, accepted the appointment of Vertebrate Paleontologist to the United States Geological Survey. This position he held to the time of his death, although the field work for the survey was terminated in 1892. His connection with the Survey gave him increased facilities for publication and for prosecuting explora-

tions in the West. He successively projected the publication of a number of large monographs on various groups of vertebrate fossils. It is a great misfortune that but two of these were ever finished by the author. The monograph of the Odontornithes appeared in 1880, and that of the Dinocerata in 1885. The others were left in various stages of incompleteness at the time of his death. The proposed volumes treated of the Sauropoda, the Brontotheridæ, the Stegosauria, Theropoda, Ornithopoda, Mesozoic Mammals, and the Ceratopsia. Most of the investigations had been completed, a large part of the plates and figures engraved, and preliminary descriptions published, but the philosophical and phylogenetic problems are largely untouched. The loss to science is greatest in the volumes relating to Reptiles, especially the Dinosauria, for in this subject Marsh stood as the sole possessor of an acute and comprehensive knowledge of one of the most wonderful and difficult groups of vertebrates known. He planned his life-work on the basis that immortality is here and not in the hereafter. It seemed difficult for him to realize the limitations of human existence and worldly accomplishment.

In the closing years of his life he had two ruling ambitions,—first, to see the main building of the Museum erected, and, second, the completion of his monographs. The accomplishment of the first is imperative and would permit of the proper care and display of the priceless treasures he has accumulated. The attainment of the second would cancel his obligations to science. Neither was realized.

As one of the trustees of the Peabody Museum and as Curator of the Geological Collections, Marsh performed his chief duties in connection with Yale University. The final transfer to the University, of all the collections he had accumulated, was made January 1st, 1898, and soon after the gift was accepted by the Corporation. These collections are so extensive as to merit particular attention, especially since they represent the most valuable part of the work of a lifetime, and form the chief monument of one of Yale's most noted men. As expressed in the deed of gift, the collections comprise:

1. The Collection of Vertebrate Fossils. This is the most important and valuable of all. It is very extensive and contains a large number of type specimens, many of them unique, and is widely known from the descriptions already published. In extinct Mammals, Birds, and Reptiles, of North America, this series stands preëminent. The collection was pronounced by Huxley, who examined it with care in 1876, to be surpassed by no other in the world; and Darwin, in 1878, expressed a strong desire to visit America for the sole purpose of seeing it. Since then it has been more than doubled in size and value, and still holds first rank. The bulk of this collection was secured in western explorations, which were extended over a period of nearly thirty years.

2. The Collection of Fossil Footprints. These specimens are mainly from the Connecticut Valley, and thus have a special local interest.

3. The Collection of Invertebrate Fossils. This includes a large amount of interesting material from many formations and localities, both in this country and in Europe. Among the series of specimens especially valuable may be mentioned several thousand from the famous Mazon Creek locality in Illinois; a very extensive collection of Crinoids from Crawfordsville, in Indiana; the largest collection of nearly entire Trilobites yet discovered; and one of the rarest series of Silurian Sponges known, including important type specimens.

4. The Collection of Recent Osteology. This is believed to be one of the most complete collections in this country for purposes of study. Special efforts have been made for many years to secure the skeletons of rare existing vertebrates from every part of the world, particularly of Mammals, Birds, and Reptiles. The collection is especially rich in Anthropoid Apes.

5. The Collection of American Archeology and Ethnology. This collection is replete in Central American antiquities, comprising several thousand, many of them unique. Among others is the famous deZeltner collection from the same region, containing a number of gold ornaments. The specimens from Mexico are also of great interest, and the series is a representative one. It includes the well-known Skilton collection.

6. The Collection of Minerals. This is a limited collection, but contains many valuable specimens, among them probably

the most interesting series known of Nova-Scotian Zeolites. These were mainly collected by Marsh, before he was graduated at Yale, during six expeditions to Nova Scotia.

Besides the six main collections named, there are several others of less value, which include fossil plants, casts of fossils, geological specimens, and recent zoological material.

To these should be added the results of his last work in endeavoring to increase the scope of the material in the Peabody Museum. For many years it was his desire to secure a collection of fossil Cycads, and when the opportunity offered, he embraced it with characteristic vigor, so that within the last year and a half the Museum has received an amount of material which in importance and quantity is second to none.

From their extensive and varied nature, these collections thus presented to the University will long afford abundant material for original investigations, and will ever attract to New Haven specialists in Paleontology and Archeology.

Professor Marsh's life was remarkably free from the petty annoyances of poor health which so often interfere with human comfort and ambitions. In the midst of his scientific work and while making plans for the growth of the Museum, he was suddenly overtaken by the malady which resulted in his death. He died of pneumonia, on March 18th, 1899, in his sixty-eighth year, after an illness of about a week. His work as an investigator in natural science, his wonderful scientific collections, and his munificence to Yale, are his legacies to the higher education of mankind.

Although Marsh was an ardent collector in Archeology, he published very little on this subject, and his paper (1866) on an Ancient Sepulchral Mound near Newark, Ohio, is practically the only one. His three mineralogical papers, published between 1861 and 1867, show the results of considerable labor and careful investigation. They treat of the Gold of Nova Scotia, a Zeolite mineral from the same region, and a catalogue of the mineral localities of the maritime provinces of Canada.

In the field of Invertebrate Paleontology, he likewise was an indefatigable accumulator of material, though after 1869 he

published nothing in this department. Two papers presented some Annelids considered as new, from the Jurassic of Germany. Another showed the origin of the double lobe-lines in *Ceratites*. His papers on American invertebrates comprised a description of a new genus of Fossil Sponge (*Brachiospongia*), a new form of Crustacean Trail from the Potsdam Sandstone, and a note on color markings in *Endoceras*. He also showed that *Palæotrochis* and *Lignilites* were not of organic origin, though the contrary had been previously supposed.

In the domain of Geology, his chief interests lay in the formations from which he secured important series of fossil vertebrates. Probably his greatest geological discovery was the Uinta Basin, an Eocene deposit of the eastern Uinta Mountains. It was first visited in 1870. Having studied most of the Tertiary lake basins in the Rocky Mountain region, he gave, in 1875, a synopsis of their geological features. As a natural result of studying Geology in Germany, he was much impressed with the methods of marking the separate horizons by means of some characteristic fossil. He believed the vertebrates were the most sensitive time-markers, and therefore endeavored to determine and limit geological horizons wholly by fossil vertebrate remains. The inherent fault of this system is that the vertebrates are not always the most highly differentiated and specialized types in any given fauna, and it is these qualities alone that can be safely employed in organic chronometry. This method is usually of great value in fresh-water deposits rich in vertebrate remains, but it can be seldom used to advantage in marine sediments or in formations containing a scanty vertebrate fauna. Thus, while the name Equus Beds is very appropriate for a horizon in the Pliocene, on account of the abundance of remains of fossil horses, the same cannot be said of the term Eosaurus Beds as an equivalent of the entire series of the Coal Measures, especially as but two vertebræ of this animal have ever been discovered. Geological facts will be found scattered through many of his publications dealing principally with fossil vertebrates. One of the latest problems to interest him was the age of the series of variegated clays extending from Martha's Vineyard south along the Atlantic coast into Maryland. His investigations led him

to refer them to the Jurassic, a formation which had been considered as absent in eastern North America.

There yet remains for consideration the real work of his life,—his publications on the Fossil Vertebrates, and it is at once evident, from a glance at the bibliography, that his chief researches were upon the Reptiles, Birds, and Mammals. There are three papers on Fossil Fishes, containing notices of several new forms, but no real research in this class was ever undertaken by him. The Amphibians also claimed but little attention, and his observations on the metamorphosis of the recent *Siredon* into *Amblystoma*, and two brief notices of amphibian footprints in the Devonian and Carboniferous, comprise the whole.

It is with extreme hesitation and a sense of inadequacy that the writer ventures to review, even in the briefest and most superficial manner, the work which undoubtedly constitutes the literary essence of his life-work. Future investigators alone can critically estimate the great mass of facts which Marsh brought out and which he wove into the departments of fossil Reptiles, Birds, and Mammals.

His most comprehensive work, and in many ways the most masterly, is the address delivered before the American Association for the Advancement of Science, at Nashville, in 1877. In this paper, entitled the "Introduction and Succession of Vertebrate Life in America," he traced the introduction of the various types of vertebrate life then known in America, beginning with the lowest fishes and ending with man. The amount of knowledge on the lower classes of vertebrates, including the reptiles, was then too meager to enable him to give more than occasional hints as to their phylogeny. But his handling of the Mammalia showed the clearest insight into the development and affinities of many of the important types, and marked him as a true philosopher.

A glance at the modern text-books of Geology and Paleontology reveals how much America has done for the fossil vertebrates in the three classes of Reptiles, Birds, and Mammals. It will also show that Marsh contributed more than any other investigator toward the prominence now accorded to the American forms.

His work on the Reptilia is not equally divided among the various orders, for the Dinosauria claimed his attention above all others. To this group he lent his best efforts, and he compassed it so thoroughly as to be its sole master. It seems only necessary in this place to notice the complete restorations he made of some of these remarkable animals. In this list are included *Anchisaurus*, *Brontosaurus*, *Laosaurus*, *Ceratosaurus*, *Camptosaurus*, *Stegosaurus*, *Triceratops*, and *Claosaurus*. It must be remembered that nearly all these animals were of gigantic stature, some of them the largest land animals yet known, and also that each restoration represents a number of separate investigations on the structure of the skull, the limbs, the vertebræ, the pelvis, etc. In most cases, only by this means was it possible to bring together gradually, part by part, until the sum of the knowledge warranted a complete representation of the skeleton. The material of many of the genera he described is still in these various stages of progress, awaiting new additions of portions yet unknown in order to form a finished conception of the entire animal. His extensive report on the Dinosaurs of North America, published in 1896, gave a synopsis of what he had accomplished up to that time, but as remarked elsewhere their philosophical treatment he had reserved for his final monographs.

Probably, among the Reptilia, next in importance to his work on the Dinosauria is that on the Mosasaurs. In this he first announced the discovery of the dermal armor, the position of the quadrate, the finding of the stapes, the columella, the hyoid, the sclerotic plates, the quadrato-parietal arch, the malar arch, the transverse bone, the pterygoids, the pterotic bone, the sternum, the anterior limbs, the posterior limbs, the length of the neck, and details of the pelvic region. Thus he contributed a knowledge of some of the most essential characters of the skeleton in this group. In other groups of aquatic reptiles, he also brought out new genera and types of structure. Prominent among these may be mentioned *Baptanodon*, a toothless Ichthyosaurian. Marsh was the first to describe the remains of fossil serpents in the western Tertiary deposits, and likewise the first to discover the remains of flying reptiles in America. The latter were of unusually large size and remarkable for the absence of teeth.

The acquisition of a unique specimen of Pterodactyl from the lithographic slates of Bavaria enabled him to supply the long sought information regarding the wing and caudal membranes. Notices of a number of new species of fossil Crocodiles, Lizards, and Turtles, complete this survey of his work on the Reptilia.

Practically, most of the present knowledge of extinct bird-life in America is contained in Marsh's publications, which include descriptions of numerous species, ranging from the Jurassic to the Post-Pliocene. Unquestionably, the one discovery which is always foremost in men's minds in a consideration of his work is the determination of an extinct order of birds possessed with teeth. The study of the Dinosaurs and Toothed Birds showed that one by one characters considered as avian were likewise present in reptiles, and that many reptilian characters were present in these primitive birds; so that at the end there did not seem much else besides feathers to distinguish them. Marsh's investigation of fossil birds led to the publication, in 1880, of his first monograph, "Odontornithes: a Monograph on the Extinct Toothed Birds of North America." In this volume, he carefully figured and described all the known types, and presented complete restorations of the two leading genera, *Hesperornis* and *Ichthyornis*. He concluded that birds most nearly resemble some of the small Dinosaurs from the American Jurassic, and that both classes originated at least as far back as the Trias or late Paleozoic, in some sauropsid type.

A discovery which rivaled that of the Toothed Birds, although not so wholly his, was the genealogy of the Horse. Huxley and Kovalevski traced the equine branch through the Pliocene to the Upper Miocene in Europe, but the true and remote ancestry remained unsolved until the American types were described by Marsh. He showed that a primitive and diminutive polydactyl horse existed in the Lower Eocene, and that from this type, by gradual and progressive change through successive horizons of the Eocene, Miocene and Pliocene, there had been evolved all the intermediate stages leading to the modern horse.

Next in importance and interest should be noticed the series of papers culminating in the monograph of the Dinocerata,

issued in 1886 by the United States Geological Survey. His work in other groups of mammals is scattered through a large number of separate papers, and contributions were made to every known order. The Tillodontia comprise one of the most remarkable of the types. Among others are the first remains of fossil Primates, Cheiroptera, and Marsupialia, known from North America. The Brontotheridæ and Coryphodontia received considerable attention. A monograph had been begun on the former, and restorations of a typical genus of each were published.

One general conclusion of much significance was the outcome of his researches on the Mammals. It was that the Tertiary genera possessed very small brains. As a single example, *Dinoceras* may be taken. This animal was but little inferior to the elephant in bulk, but its brain capacity was not more than one-eighth that of existing rhinoceroses.

The first Mesozoic Mammal in America was described by Emmons, in 1857, from the Triassic of North Carolina. Marsh, by his extensive discoveries, was enabled to fill up the gaps to the Tertiary with many genera and species from the western Jurassic and Cretaceous. Probably nine-tenths of all the Mesozoic Mammals known in the world were described by him, and while these remains are of great interest, yet from their fragmentary condition they are not of the highest scientific value, because little is known beyond the jaws and a few limb bones.

In closing the outline of the discoveries made by this investigator, one cannot help being impressed with their signal brilliancy, their great number, and especially by their unique importance in the field of organic evolution. Were all other evidence lost or wanting, the law of evolution would still have a firm foundation in incontrovertible fact. The study of variation and embryology in recent animals gives hints as to the truth, but Paleontology alone can give the facts of descent.

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ART. XLVI.—*The Camden Chert of Tennessee and its Lower Oriskany Fauna;* by JAMES M. SAFFORD and CHARLES SCHUCHERT.*

Part I. The Camden Chert.

By JAMES M. SAFFORD, State Geologist.

IN March, 1855, the writer discovered in Benton County, Tennessee, at several points, excellent outcrops of Lower Helderberg shales and limestones, very rich in fossils. The discovery was important, since it settled the question as to the presence of the Lower Helderberg, as a distinct formation, in Tennessee, west of the meridian of Nashville. In subsequent years, this discovery also led to a recognition of the chert now referred to as Oriskany, which I have designated the Camden chert for the reason that at Camden, the county-seat of Benton, is seen one of its best exposures.

One of the localities discovered in Benton County was a bluff on Big Sandy River, about five miles from its mouth, at a point then in Henry County, and known as the old William's Mill Site. This locality is referred to in "Geology of Tennessee," 1869. As stated on page 325 of that book, there are here exposed about 50 feet of bluish limestone, mostly shaly. Above this and running back on a slope from the precipitous portion of the exposure, "are loose, angular, flinty masses, containing the fossils of the rocks below, and derived from cherty layers not seen." The fossils in the chert were not numerous nor in good condition, but what was seen of them led, at the time, to the conclusion stated.

In 1884, I recognized the chert at Camden as a distinct formation. I had, in passing through the country, seen this horizon and had referred it without special examination to the "Silicious Group" (Lowest of Subcarboniferous), outcrops of which, very like the chert of Camden, are seen at many points in Benton and counties north and south of it. In my excursion of 1884, however, I stopped for some time at Camden to study the formations. The fossils in the chert arrested my attention, and reminded me of those in the flints seen at William's Mill in 1855. But at Camden, the chert was in comparatively great force, at least 60 feet of it being exposed. At first, I was inclined to consider the chert a division of the Lower Helderberg, but subsequent studies of the fossils at home forced me to the conviction that, as a group, they must

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be Oriskany. The fact that the formation was one of chert also pointed to this.

Afterwards, in 1885, 1886, and 1887, I visited localities where I thought the Camden might outcrop. One of these is Big Sandy Station, in Benton, on the Memphis branch of the Louisville & Nashville Railroad, and near the point where the road crosses Big Sandy River. Here I found the chert well developed and abounding in fossils. The outcrops are as extensive and as good as at Camden. For several miles south of Big Sandy, the chert appears on the hillsides as loose angular gravel.

Five miles south, on the Lower Camden road, Lower Helderberg limestones are seen cropping out from beneath Camden chert, with Tertiary beds also overlapping all in unconformable contact.

In Henry County the Camden chert outcrops in considerable areas, west and south of the William's Mill locality. It is seen in limited thickness above the Lower Helderberg in Decatur County, and in the same relation, east of the Tennessee River, in Stewart County. In the latter locality, it outcrops in the bluff on the Cumberland River below Cumberland City. The greatest development of it, however, is on the west side of the Tennessee River, in a strip of country lying in Henry, Benton, and Decatur Counties.

In 1897, I called the attention of Mr. Schuchert to the Camden chert, at the same time trusting he might be able to visit the Camden locality. This he did, collecting a series of fossils, which he studied, kindly giving me the results. I am under special obligation to him for this visit.

Part II. The Camden Lower Oriskany.

By Charles Schuchert.

In the spring of 1897, the writer collected for the U. S. National Museum Lower Helderberg fossils in western Tennessee, and while in Nashville, Professor Safford also directed his attention to a lot of Camden chert organisms. Since no strata of Oriskany age had been recorded in Tennessee, the importance of determining the equivalency of the Camden chert with other regions made it desirable to know more of its fauna, and with that object in view, a collection was made at Camden.

The fossils of the Camden chert are, as a rule, natural casts of both the interior and exterior of the organism, and preserve the fined markings in detail. This fauna is closely related to that described by Meek and Worthen* from the "Clear Creek

* Geol. Surv., III, vols. i, ii, and iii.

Limestone" of southern Illinois, Alexander, Jackson, and Union Counties. From this region are known but 11 species, and 8 of these are also found in Tennessee. They are *Anoplia nucleata, Anoplotheca flabellites, Eatonia peculiaris, Spirifer worthenanus, S. hemicyclus, Megalanteris condoni, Amphigenia curta* and *Strophostylus cancellatus.*

The "Clear Creek limestone" of Illinois is intimately connected with the Lower Helderberg below, and is not less than 200 feet thick, being followed by a "quartzose sandstone" from 40 to 60 feet in thickness. The latter is probably equivalent to the Upper, or typical, Oriskany of New York, and does not appear to be present in western Tennessee. From Professor Safford's description of the Camden chert, it is evident that the Lower Oriskany thins rapidly southward. In Tennessee, it is about 60 feet in thickness, while it is not less than 200 feet thick in Illinois exclusive of the Upper Oriskany, which is entirely absent in the former state.

The "Camden chert" fauna contains 32 species, and 6 of these are restricted to southern Illinois and western Tennessee. Of the entire fauna, 24 species are found either in the Lower Helderberg or in the Lower Oriskany of other regions, and 20 occur in the Upper Oriskany or Corniferous. After removing the 13 species common to both the Lower and Upper Oriskany, and the two restricted forms, 17 remain. Of these 10 occur either in Lower Helderberg of Lower Oriskany rocks of other regions, while 6 are found in higher beds. This evidence, therefore, indicates clearly a Lower Oriskany age for the "Camden chert" of Tennessee and the "Clear Creek limestone" of Illinois, which indication is the more marked because of the absence here of such characteristic Upper Oriskany species as *Hipparionyx proximus, Chonostrophia complanata, Spirifer arenosus, Rensselæria ovoides, Meristella lata, Camarotœchia pleiopleura, C. barrandei,* or *C. speciosus.*

Lower Oriskany fauna of the Camden Chert of Camden, Benton County, Tennessee.

	In Lower Oriskany elsewhere.	In Upper Oriskany elsewhere.
Zaphrentis rœmeri Hall?	L. H.*	
Pholidops terminalis Hall	×	×
Hipparionyx proximus Vanuxem? A very small specimen if this species	×	×
Chonetes mucronatus Hall?		×
" melonica Billings	×	×
Chonostrophia reversa (Whitfield)		U. H.

* L. H. = Lower Helderberg; U. H. = Upper Helderberg. This list is based on the collection in the U. S. National Museum.

	In Lower Oriskany elsewhere.	In Upper Oriskany elsewhere.
Stropheodonta (Lepstrophia) perplana (Conrad)	×	U. H.
Orthothetes woolworthanus Hall	×	
Anoplia nucleata Hall	×	×
Cyrtina affinis Billings	×	×
Metaplasia pyxidata Hall	×	×
Spirifer hemicyclus Meek and Worthen	×	
" tribulis Hall	×	×
" worthenanus Schuchert	×	
Anoplotheca flabellites (Conrad)	×	×
Meristella lævis (Vanuxem)	×	
" sp. undet.		
Camarotœchia tethys (Billings) ?		U. H.
Atrypa reticularis Linne	×	×
Eatonia pecularis (Conrad)	×	×
Amphigenia curta Meek and Worthen ?	×	
Rensselæria ovoides (Eaton) ?	×	×
Megalanteris condoni (McChesney)	×	
Tentaculites acula Hall	×	×
Avicula cfr. obscura Hall	L. H.	
Actinopteria cfr. textilis Hall	×	
Acrocoulia magnifica (Hall) ?		×
Acrocoulia (Orthonychia) tortuosa (Hall) ?	×	×
Diaphorostoma turbinata (Hall)		U. H.
Strophostylus (?) cancellatus Meek and Worthen	×	
Phacops cristata Hall		×
Ostracoda.		
Total 32 species	24	20

ART. XLVII.—*Recent discovery of rocks of the age of the Trenton formation at Akpatok Island, Ungava Bay, Ungava;* by J. F. WHITEAVES.

WHILE accompanying the Hudson Bay expedition despatched by the Canadian government in 1897, in the sealing steamer "Diana," Dr. R. Bell, of the Geological Survey of Canada, spent the 13th of September on Akpatok Island, on his way from Ashe Inlet to Fort Chimo. In a preliminary report on his explorations for that year,* Dr. Bell says: "The portion of the island which I saw (from the northern end to the middle of the east side) consists of unaltered gray limestone in horizontal beds, and it presents a perpendicular wall 400 or 500 feet high all along." "This sea-wall is clean-cut and the beds appear thick and solid, but wherever their edges have been long exposed to the weather, or in the hill-sides and ravines of the interior, they split up into thinner layers." "Some fragments observed in one place had the appearance of lithographic stone." "I was enabled to land opposite the place where the Diana anchored, as already mentioned, about the middle of the eastern side, and I improved the opportunity to collect fossils, which, however, were not abundant." "Those obtained indicate the Hudson River formation."

When this last sentence was written, the specimens that it refers to had not been unpacked. Since the publication of the Report from which it and the four preceding sentences are quoted (in May, 1898), these fossils have been examined by the writer, and it at once became obvious, first, that they indicate a little lower geological horizon than the Hudson River formation, viz., that of the Trenton limestone; and, secondly, that they are remarkably similar to the fossils of the Trenton formation of the Red River valley in Manitoba. The collection consists of fifteen species, but two of these are imperfect casts of the interior of shells of gasteropoda, that can only be determined generically. Of the thirteen that remain eleven had previously been found in the Manitoba Trenton, and nine are species that are common at East Selkirk and Lower Fort Garry. The two fossils of which by far the most specimens were collected are *Streptelasma robustum* and *Cyrtoceras Manitobense*. The former is a rather large rugose coral, the types of which are from the Red River valley in Manitoba.

The following is a list of the species represented in the collection, as far as they can be determined.

* Summary Report of the Geological Survey of Canada for 1897, page 82.

LIST OF FOSSILS FROM THE TRENTON FORMATION AT AKPATOK ISLAND, COLLECTED BY DR. BELL IN 1897.

RECEPTACULITIDÆ.

Receptaculites Oweni Hall.
A very small and worn but fairly characteristic fragment.

ZOANTHARIA.

Streptelasma robustum Whiteaves.
About thirty specimens, of all sizes.

Calapœcia Canadensis Billings.
One specimen.

BRACHIOPODA.

Rafinesquina lata Whiteaves.
One ventral valve.

Leptæna unicostata Meek and Worthen.
A tolerably well preserved ventral valve that is apparently referable to this species.

Plectambonites sericea (Sowerby).
A few specimens.

Orthis tricenaria Conrad.
An unusually large ventral valve.

Orthis (*Dinorthis*) *Meedsi*, var. *arctica* Schuchert.
Three imperfect and badly preserved specimens which Mr. Schuchert thinks look very much like Baffin Land specimens that he is describing under this name.

Orthis (*Hebertella*) *bellarugosa* Conrad.
One good specimen that has been identified with this species by Mr. Schuchert.

Orthis (*Dalmanella*) *testudinaria* Dalman.
A few imperfect specimens.

Platystrophia biforata (Schlotheim).
Two imperfect ventral valves.

? Rhynchotrema inæquivalvis (Castelneau).
An imperfect ventral valve, with the cardinal area not visible.

GASTEROPODA.

Trochonema or *Pleurotomaria*. (Species indeterminable.)
A cast of the interior of the last volution and last but one.

Hormotoma. (Species indeterminable, but apparently like *H. Salteri* Ulrich.)
A cast of the interior of three of the volutions.

CEPHALOPODA.

Cyrtoceras Manitobense Whiteaves.
About thirty well preserved but much worn fragments, from less than an inch to nearly two inches in length.

Ottawa, March 23d, 1899.

ART. XLVIII.—*Studies in the Cyperaceæ;* by THEO. HOLM.

X. *Fimbristylis* Vahl; an anatomical treatise of North American species. With fourteen figures in text, drawn from nature by the author.

THAT purely floral characters are insufficient for the establishment of genera has been proved by several botanists in recent years. This is especially the case with large orders, where a number of species are to be classified so as to demonstrate, at least, a supposed relationship. It is not uncommon that herbalists content themselves by studying only the floral structure and matching the details with some old illustration or analytical key; but there is, however, more than that to be considered and looked upon, as affinity and relationship. The establishment of natural orders is, of course, a progress, but, to say the least, the genera themselves are often so badly understood and so arranged, that we obtain no more knowledge of the real affinities than if we had followed the system of Linnæus: Monandria, Diandria and so on. It is very common to see species arranged in genera widely apart, on account of the stamens and stigmata being different in number, while the plants otherwise show the same habits and internal structure. Our genus *Fimbristylis* furnishes a good illustration. Merely because some species have two or three stigmata, this genus has been divided into *Dichelostylis* and *Trichelostylis;* and the fact that the base of the style is persistent in some species, but only for some time, has caused the separation of the genera *Isolepis* and *Oncostylis.** Furthermore these genera have been considered as subgenera of *Scirpus* or even as close allies of *Heleocharis*, a consideration, however, that cannot possibly have been based upon observations in the field. But to Bentham and Asa Gray such characters were of less importance, and these authors were liberal enough to include a number of species as true *Fimbristyles*, even if the floral characters did not come exactly within the scope of the original diagnosis or conception of the genus as understood by Vahl. Finally the anatomical study of a number of genera of the *Cyperaceæ* has shown us that certain analogies exist which must be considered as valuable to the study of mutual affinities, promulgated by Schwendener, Palla† and Rikli.

* It was Martius (Flor. Brasil.) who substituted the generic name *Oncostylis* for *Bulbostylis*, which appears in the Conspectus generum, because DeCandolle had already used *Bulbostylis* to designate a genus of *Compositæ*.

† Palla Ed. Zur Kenntniss der Gattung "Scirpus." (Engler's botan. Jahrbücher, vol. x, Leipzig, 1889, p. 293.)

Considering the genus Fimbristylis in North America not only "sensu strictiori," but including the species which Torrey referred to *Isolepis: stenophylla, ciliatifolia, Warei* and *capillaris* R. et S., we cannot avoid noticing that the general habit of these plants, both annuals and perennials, is very much the same. A dense cespitose growth is characteristic of most of our species; the leaves are generally narrow with short sheaths, and the flowers are arranged in true spikes, either borne on long peduncles constituting open cymes, or sessile in small heads. While a pubescence is rarely observed in *Cyperaceæ*, it is not uncommon in *Fimbristylis*, of which several species have the leaves, stems, involucres and scales clothed with short hairs. In examining the inflorescence, the spikes are mostly, as stated above, arranged in open cymes, where the terminal spike is almost sessile and overtopped by the lateral ones. In *F. castanea* and *F. thermalis* several lateral spikes are borne on long peduncles, but with no further ramifications, representing respectively a di- or pleio-chasium. A similarly constructed cyme is, also, characteristic of *F. laxa* in plants growing in the vicinity of Brookland, D. C.; in specimens from Eustis, subtropical Florida, the lateral inflorescences are, on the other hand, decompound, thus agreeing with *F. spadicea*. The pleiochasium in *F. puberula* is either simple or decompound; in the first case the spikes are considerably larger than in the last, where the spikes consequently are more numerous. The most decompound inflorescence is, however, to be found in *F. autumnalis*, where the secondary branches are pleiochasia, the tertiary, on the contrary, passing over into monochasia of only two spikes, a terminal and a lateral. While in *F. capillaris* the inflorescence is typically a pleiochasium, it is not unusual to meet with specimens where the flowers are reduced to a single spike, at the base of which a long involucral bract is often noticeable, but without supporting any lateral branch. Similar empty involucral leaves, but reduced to scale-like, long-pointed bracts, occur also at the bases of several of the spikes, indicating the place of non-developed inflorescential branches. In species with sessile spikes, *F. Warei* and *F. stenophylla*, the composition of the inflorescence becomes more indistinct, since all the peduncles are very short and the characteristic clado-prophyllon entirely suppressed, a fact that is known also from other genera of *Cyperaceæ* with similarly aggregated spikes: species of *Cyperus, Dichromena, Scirpus, Carex* and others. But where a clado-prophyllon is developed, this is readily noticed at the very base of each lateral peduncle as a tubular sheath, more or less puberulent in our species of *Fimbristylis*. It varies somewhat in shape, being compressed in *F. autumnalis* and its more southern ally *F. complanata*,

or bicarinate in *F. castanea* and *F. spadicea*, or it is cylindric as in the other species; the apex is prolonged into two subulate teeth in *F. laxa* and *F. castanea*, but merely slightly oblique in the others. While the inflorescence of *Fimbristylis* does not show any remarkable deviation from that of other *Cyperaceæ*, we have observed in the disposition of the leaves a very peculiar exception from the ordinary rule in this order, at least in some species. As invariably quoted in botanical manuals, the tristichous leaf-arrangement is the characteristic one of the *Cyperaceæ*, while on the contrary the distichous that of the *Gramineæ*. It would hardly be natural to suppose that any such rule should be stable for either of these orders, since exceptions are known if not from the leaves then at least from the arrangement of the spikelets and the inflorescential branches. We might merely call attention to the panicles of a number of *Gramineæ*, of which the branches are not distichous; besides that the spikelets are sometimes spirally arranged, as for instance in species of *Eragrostis*. In the *Cyperaceæ* the distichous arrangement of the flowers with their bracts is well known as the very characteristic of *Cyperus*, *Dulichium*, partly also of *Scleria* and *Dichromena*. But the arrangement of the stem-leaves has, so far, usually been described as tristichous in the *Cyperaceæ*, in spite of the fact that Kunth, in his diagnosis of *F. autumnalis*, characterized the leaves as "distichis," a statement which is absolutely correct. The leaves of this species have laterally compressed sheaths, which soon become split, and the blades are furthermore held in a very peculiar position: with the one margin turned towards the axis or the flower-bearing stem. Although the leaf-blades are not isolateral, they invariably show this position, a fact that we have never noticed before in any of our American species with corresponding anatomical structure excepting in *F. complanata*. The distichous arrangement of the leaves is, however, also to be seen in *F. castanea* and *F. spadicea*, but the leaf-blades are not turned to the side in these species; they occupy the usual position as dorsiventral leaves. Considered from a morphological view-point, it seems strange that such disposition of leaves should be found in a genus like *Fimbristylis*, in which all the other foliar organs, involucral-leaves and floral bracts are arranged in spirals; it would seem more natural to a genus like *Cyperus* or *Dulichium* with the distichous flowers. And by examining the internal structure of such leaves, it seems still more surprising that we find a number of analogies rather than important variations. Furthermore when we compare our North American species with each other, it will be seen from the following pages, that even if they inhabit localities differing greatly in climate and soil, their internal

structure does not seem to be influenced to such an extent as to render it impossible to detect several and very gradual transitions. The modern, but often too superficial and hasty classification of plants as Xero- and Hydro-phytes, is not by any means applicable to our genus, at least not to its North American representatives. If such types of plants, Xero- and Hydro-phytes, really exist, it must be proved not by observations in the field alone, but by a very close study of their structural peculiarities. The mere fact that such and such species inhabit dry, sandy places or marshes, ponds, etc., does not necessitate the plants in question to be considered as either xero- or hydro-philous species; their internal structure must be carefully examined before any conclusion can be drawn, as to whether these plants are "solely adapted" to these special environments. As regards our species of *Fimbristylis* it might seem very tempting to classify these in this way: *F. capillaris*, *F. Warei*, *F. stenophylla* and *F. ciliatifolia* as xerophytes, and the remaining species as hydrophytes, but their anatomical structure does not seem to justify any such classification. In order to facilitate the anatomical comparison of the material, which we have examined, it may be well to enumerate the various localities as follows: *F. autumnalis* was collected in wet sandy or clayish soil in the vicinity of Washington, D. C., and in low sandy places near Eustis, subtropical Florida; *F. castanea* was from brackish marshes near the coast of Maryland; *F. spadicea* and *F. puberula* both from wet, sandy soil near Eustis, Florida; *F. laxa* from low meadowland, rather dry soil, near Brookland, D. C., as well as from low, sandy soil near Eustis, Florida; *F. thermalis* from hot sulphur springs near Golkonda, Nevada; *F. capillaris* from dry, sandy soil near Washington, D. C., and Eustis, Florida; *F. ciliatifolia* from dry, sandy fields in Alabama, and finally *F. stenophylla* and *F. Warei* from dry, sandy soil in the High-Pine-woods near Eustis, Florida. Besides these we have, also, examined some specimens of *F. complanata* and *F. capillaris* from Montevideo, Uruguay, which together with a number of other *Cyperaceæ* were presented to the writer through the courtesy of Professor Arechavaleta, Director of the National Museum at Montevideo.

In discussing the anatomy of the vegetative organs of these species, we will begin with

The leaf.

By its greater ability to vary, the leaf appears to illustrate the species better than the stem or root. Considering the mere outline of the leaf, three types are readily distinguished:

(1) the relatively broad and flat, as we find it in *F. autumnalis*, *F. thermalis*, *F. spadicea*, *F. puberula*, *F. complanata* and *F. laxa;* (2) the semi-cylindrical in *F. castanea* and (3) the approximately triangular in the remaining species. Very characteristic of the leaves of the first category is the more or less, but always very conspicuous, asymmetric blade, in contradistinction to those of the other species, a fact that has, also, been recorded by Rikli as common to *F. glomerata* (Nees) and *F. paupercula* (Bklr.) In *F. autumnalis* the leaf, as will be seen from the accompanying illustration (fig. 1), is flat and strictly dorsiventral; only the midrib is somewhat projecting on the lower surface of the blade, and this is due to its larger support of stereome. The upper face is perfectly smooth,

FIG. 1. Transverse section of half of the leaf-blade of *F. autumnalis*. × 75.

and there is nothing in the outline to indicate the peculiar position of the blade, as we have mentioned already, being placed edgewise by the twisting of the leaf-sheath. This form of leaf must not be confounded with the sword-shaped leaves of *Iridaceæ*, because both faces are equally well developed in *Fimbristylis autumnalis*, besides in *F. complanata*.

The leaf is more likely to be compared with that of a mature *Eucalyptus* or of our evergreen species of *Smilax*, of which the leaves show a similar position. It is strange to see that such peculiar leaf-position is said to be either "a xerophytic character of bog-plants or a natural adaptation of desert-plants." However in these species of *Fimbristylis* the leaf-blade is developed with this position immediately after germination, and we have not noticed any exceptions to this rule in specimens from less dry situations, nor in plants growing in *Sphagnum*-moss. It is a character that seems to be peculiar to these two species, but which cannot possibly be considered as having originated through any means of adaptation, since the structure is identical with that of the other species, in which the ventral leaf-face is turned towards the stem.

While the epidermis of the upper face in *F. autumnalis* consists only of one layer of large, thin-walled cells of equal width all through the blade, we find in *F. complanata* several layers, representing a typical water-storing tissue. Among the

other species *F. laxa* (fig. 2) comes nearest to *F. autumnalis*, since the superior epidermis is only composed of one layer, but the leaf is much narrower and the blade is not placed edgewise; furthermore the leaves are tristichous. In *F. spadicea* the accompanying figure (fig. 3) shows that the epidermis has been developed in a few strata, but only in certain places, between the mestome-bundles. It is very strange that this species has often been considered as identical with *F. castanea* or at least as the type, since both are so very different,

FIG. 2. Transverse section of leaf-blade of *F. laxa*. ×75.

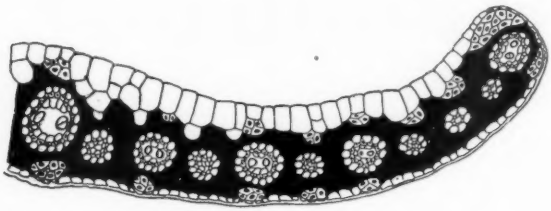

FIG. 3. Transverse section of half of the leaf-blade of *F. spadicea*. ×75.

when considered from an anatomical point of view. By examining the leaf of *F. puberula* (fig. 4) we notice that the upper surface is occupied by a huge mass of colorless and relative large cells, which represent an epidermis of several layers. Besides this the epidermis of the inferior surface is developed as a dense covering of long, unicellular hairs, a fact that would

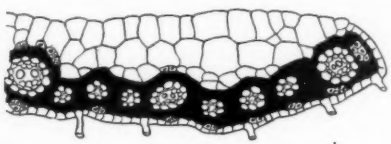

FIG. 4. Transverse section of half of the leaf-blade of *F. puberula*. ×75.

seem to point towards some special adaptation, "a xerophytic character developed in a hydrophilous plant"; yet the species is neither a hydrophyte or xerophyte as these terms are gen-

erally applied. A structure similar to that of *F. puberula* but without hairs is to be found in *F. thermalis* (fig. 5), of which the writer received some excellent material from Dr. E. L. Greene. The leaf-blade is here broad and very thick from the immense layers of colorless tissue on the upper surface, the function of which cannot possibly be for the storage of water, since the specimens were growing in hot sulphur springs. *F. castanea* exhibits a very peculiar shape of leaf, this being semi-cylindrical (fig. 6), and of which the upper surface shows a

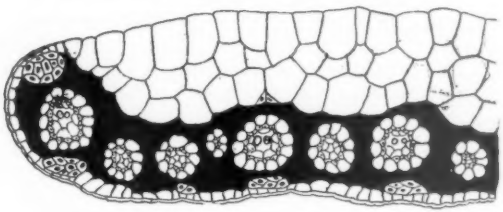

FIG. 5. Transverse section of half of the leaf-blade of *F. thermalis*. × 75.

still larger development of colorless tissue than any of the other species we have examined. It was rather surprising to find this narrow leaf developed on a species that inhabits brackish marshes, which are not liable to become dried out during the summer. It is actually the narrowest leaf we have observed in any of the North American species of *Fimbristylis*, in proportion to its length, and the only species that possess approximately as narrow leaves are just those which inhabit a very dry and sandy soil: *F. capillaris*, *F. ciliatifolia*, *F. Warei* and *F. stenophylla*. The accompanying figures (figs. 7, 8 and 9) illustrate transverse sections of leaves from the latter three species, and we notice at once the very narrow, almost triangular outline from the strongly projecting midrib. No large tissue for water-storage is developed in any of these species, but the cells of epidermis are on both surfaces relatively wide, and sometimes a double epidermis may be developed between the mestome-bundles, in both *F. ciliatifolia* and *F. Warei*. Characteristic of the leaf of *F.*

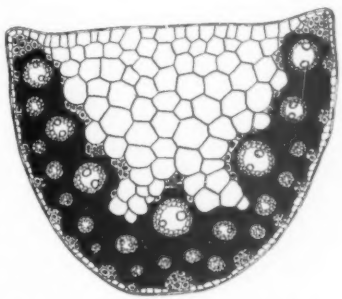

FIG. 6. Transverse section of leaf-blade of *F. castanea*. × 75.

stenophylla (fig. 9) are the double rows of diverging, pointed hairs along the margins and the ribs on the lower surface of the blade.

Although *F. complanata* is not a native of this country, we have examined some specimens, as stated above, from Uruguay, which were originally labeled *F. autumnalis*, to which it shows a very pronounced habitual resemblance. The position of the leaves are exactly the same, distichous with the blade held edgewise; besides the inflorescence is very rich-flowered. However, while we examined the anatomy we became aware of the fact, that in this respect our plant showed a leaf-structure different from that of *F. autumnalis*, but almost exactly like that of *F. thermalis*. In order to secure correct identification of this South American species, we sent specimens to Mr. C. B. Clarke at Kew, who kindly replied that the plant was Link's *F. complanata* var. *Kraussiana*. If Dr. Bœckeler had known of the structural divergencies between this and *F. autumnalis*,

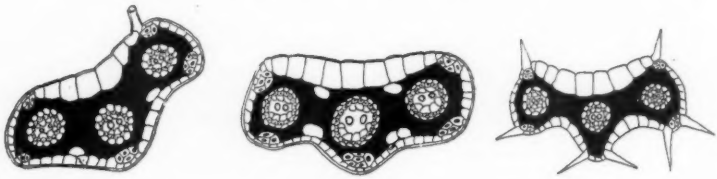

FIG. 7. FIG. 8. FIG. 9.

Leaves of *F. ciliatifolia*, *F. Warei* and *F. stenophylla*; transverse sections. × 75.

he would hardly have considered them as but one species, even if the outer likeness is very striking.

If we now compare the leaves, of which we have drawn some transverse sections from the middle part of the blade, it is readily seen that the outline and the structure of the upper epidermis presents certain features for distinguishing the species. Nevertheless these leaves demonstrate several intergradations, thus the various forms may be easily deducted from one another. The epidermis of the upper surface is either developed as one single layer of large, bulliform cells, or as several strata, that cover the mesophyll. None of these strata are, however, differentiated in such a way as to have the function of opening or closing the leaf, the so-called "Gelenkcellen" of the Germans, common to *Cyperaceæ* and *Gramineæ*.

In passing, to describe the minor details of the leaf-structure, we observed the cuticle to be very thin and smooth in *F. autumnalis*, *F. laxa* and *F. complantata*, less so in *F. spadicea*; in the remaining species the cuticle is very thick, but smooth, not granular. The epidermis of the lower surface is almost

smooth with no furrows, and consists usually of smaller cells than that of the upper, and is frequently developed into unicellular hairs or very minute spines, which are directed upwards. The stomata are restricted to the lower epidermis, where they form longitudinal rows outside the mesophyll between the mestome-bundles. Characteristic of the stomata is the deep and somewhat narrow air-chamber, which we have noticed in most of our species with the exception of *F. castanea*, , where it is shallow and wide. The guard-cells are projecting in *F. autumnalis*, *F. laxa*, *F. puberula*, *F. spadicea* and *F. complanata*, but not in the other species; they are extremely thick-walled in *F. castanea*.

Similar to all the other *Cyperaceæ*, examined so far, silicious cones are observable in the epidermis-cells that cover the stereome. As regards mechanical support most of our species possess a well-developed stereome, the location of which can be seen on the sections, figured above. It accompanies the larger mestome-bundles as hypodermal groups on the lower surface of the blade, while on the upper it is restricted to the margin. A few thin-walled stereome-cells may be found above some of the largest mestome-bundles, but separated from these by mesophyll. Although the stereome does not form any sheaths around the mestome-bundles, it nevertheless renders a strong support to the leaf by its very thick-walled cells, and is altogether very well represented in our species of *Fimbristylis*, with the only exception of *F. autumnalis* and *F. laxa*, in which it is relatively thin-walled.

The chlorophyll-bearing tissue, the mesophyll, occupies only a small part of the leaf-blade, since it is generally traversed by a number of mestome-bundles, which are especially large in the narrow-leaved species, such as *F. capillaris*, *F. Warei*, etc. It forms a homogeneous tissue on both faces of the leaf, and the cells are true palisades, arranged radially around the mestome-bundles. Furthermore this tissue is very compact in our species excepting in *F. laxa*, of which some specimens from Florida showed wide lacunes; and *F castanea*, in which the palisade-cells are almost star-shaped, leaving numerous and quite large intercellular spaces. Tannin was observed to be very plentiful in this tissue, especially in *F. spadicea*, *F. puberula* and *F. thermalis*.

Considering the mestome-bundles, these are all arranged in a single plane in the leaves of *Fimbristylis;* they vary in proportion to size and outline, the larger being more or less oval, the smaller constantly orbicular. They are imbedded in the mesophyll, and are, as we have seen above, in no connection with the stereome, hence they are "pure" mestome bundles.

Besides being surrounded by the radially arranged palisade-cells, the mestome-bundles possess, also, a completely closed parenchyma-sheath of small, thin-walled cells, which contain chlorophyll. Inside of this parenchyma-sheath there is a mestome-sheath, thin-walled in *F. autumnalis* and *F. thermalis*, but more or less thickened in the other species. The peculiar "inner chlorophyll-bearing sheath," which we described in a previous article upon *Lipocarpha*,* occurs, also, in *Fimbristylis*, and not only in the genus "sensu strictiori," but also in those American species of *Isolepis* which we have included in the former genus. We found the structure of this sheath to be identical with that of *Lipocarpha*, being composed of much larger cells than the mestome-sheath; also by being closed in the small, orbicular bundles, but interrupted in the larger (fig. 10). The cell-content seems, also, to present the same deep green color as noticeable in *Lipocarpha*.

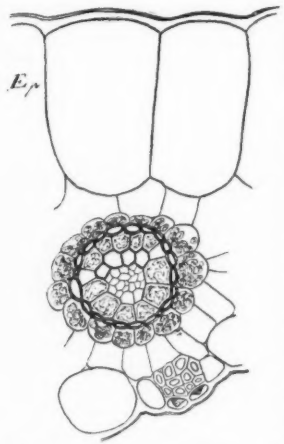

FIG. 10. Transverse section of a mestome-bundle from the leaf of *F. autumnalis*; *Ep.* = epidermis of the upper surface. ×400.

As regards the hadrome and leptome these have, naturally, attained their highest degree of development in the largest mestome-bundles, where these tissues are sometimes separated from each other by one or more layers of thick-walled mestome-parenchyma, as in *F. castanea*, *F. puberula*, *F. spadicea* and *F. complanata*. The presence of the inner, chlorophyll-bearing sheath in our species of *Fimbristylis* will necessarily place the genus as a member of Rikli's "*Chlorocyperaceæ*," among which this author has not, however, enumerated any of the *Isolepis*-species examined by him. Moreover the morphological and anatomical diagnosis of *Isolepis*, as demonstrated by Palla, does not seem comparable with any of the North American plants which by Torrey were referred to this genus. Our species differ very much from *Isolepis* proper by their morphological characters, also by their internal structure. And even if the inner, green sheath is not a constant character to all species in certain large genera such as *Heleocharis* and *Cyperus*, as demonstrated by Rikli, it would not be correct to consider our

* This Journal, vol. vii, p. 172.

American species as only anatomically distinct from other representatives of *Isolepis*. Our narrow-leaved species of *Fimbristylis* do not show any very important anatomical or morphological characters by which they should be considered as distinct from the others with somewhat broader leaves; they do not present any such divergencies which induced Rikli to separate his *Chlorocyperus* and *Chlorocharis* from *Cyperus* and *Heleocharis*; besides they lack the very conspicuous character: "bractea infima erecta, inflorescentiam quasi lateralem sæpissime excedens, caulem continuans" as pointed out by Bentham.

The stem.

The stem above-ground, which bears the inflorescence at its apex, varies from cylindrical to being almost flattened, but shows, nevertheless, a very uniform structure in our species. The singularly flattened stem of *F. autumnalis* (fig. 11) and *F. complanata* corresponds well with the flat leaves, which are turned edgewise in these species. In *F. castanea*, *F. thermalis*,

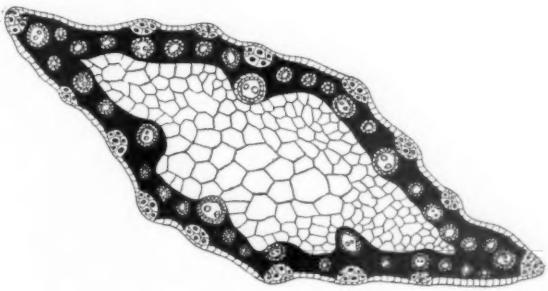

FIG. 11. Transverse section of the stem of *F. autumnalis*. ×60.

F. spadicea and *F. puberula* the outline is almost cylindrical; in *F. laxa* it is polyedric; in *F. Warei* and *F. stenophylla* the outline is decangular, while *F. capillaris* possesses a penta- or hexa-gonal stem. When compared with the leaf the stem-structure shows many analogies, but the mechanical tissue has here attained a stronger development, the mestome-bundles are arranged in several, more or less concentric, bands and the bark-cells are not arranged radially around the mestome-bundles in all the species.

While the cuticle of the stem shows the same slight variation as we noticed in the leaves, the epidermis is often more thick-walled and does not develop such dense pubescence as in

the leaves. Grooves or furrows are observable in some species, but they are rather shallow and wide; thus the stomata, which are located in these, are freely exposed. We notice the same variation in the relative width of the epidermis-cells as in the leaves; besides the characteristic cones are very numerous outside the hypodermal stereome. The bark-parenchyma forms, similar to the mesophyll, a homogeneous tissue of palisade-cells, which are arranged radially towards the center of the stem in the majority of our species, but not in *F. capillaris*, *F. ciliatifolia*, *F. Warei* and *F. stenophylla*. The bark-parenchyma is commonly quite solid with no lacunes, but the intercellular spaces are numerous and wide in *F. castanea*, *F. thermalis* and *F. puberula*. It is, furthermore, to be pointed out that the bark-palisades, which border on the leptome-side of the innermost mestome-bundles in *F. castanea*, do not radiate towards the center of the stem, but towards the center of the bundle. Cells containing tannin were, also, observed in the stem of various species, but not so abundant as in the leaves. We have stated above, that the stereome is more strongly developed in the stem than in the leaves. This is readily noticed if we compare the leaf-section of *F. castanea*, for instance, with the accompanying figure of a part of its stem (fig. 12). This section shows a number of very large

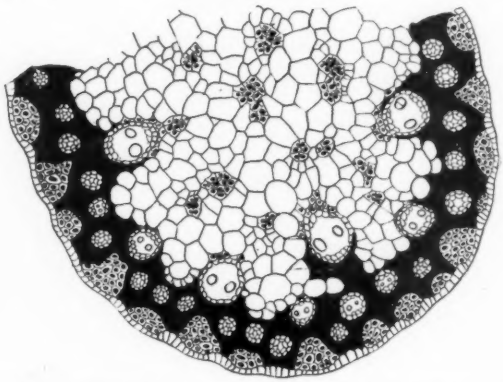

FIG. 12. Transverse section of half of the stem of *F. castanea*. × 75.

hypodermal stereome-bundles, most of which are situated deep into the bark between the outer band of mestome-bundles. There are, also, a few scattered and very small groups of stereome on the hadrome-side of the innermost bundles. Finally in the pith itself we observed quite a number of stereome-bundles, which were not arranged in any order, and

of which only a few surrounded minute leptomatic-bundles. Similar stereome-bundles imbedded in the pith were, also, observed in *F. spadicea*, but not in any of the other species, where this tissue is either strictly hypodermal or may be found on the hadrome-side of the innermost mestome-bundles. The largest part of the stem is occupied by a solid pith, mostly consisting of polyedric cells, when considered in transverse sections. With the exception of *F. spadicea*, of which the pith contained much tannin, this matter was not observed in the pith of any of the other species.

In regard to the mestome-bundles these are more numerous in the stem than in the leaf; they may form one single and almost concentric band as in *F. capillaris* (fig. 13), *F. Wurei*, *F. ciliatifolia* and *F. stenophylla*, or several as in the other species. They show exactly the same variation as those in the leaves, and the smallest, the orbicular ones, are invariably the most numerous and located near the periphery. Inside of these may be a second band of somewhat larger bundles as in *F. autumnalis*, *F. puberula*, *F. complanata*, *F. laxa* and *F. spadicea*, while even a third band is present in *F. castanea* and *F. thermalis*, these two species being the most robust of this genus in North America. The minor structure of the mestome-bundles is the same, all possessing a parenchyma-, a mestome- and an inner, chlorophyll-bearing sheath; besides the relative development of the leptome and hadrome corresponds with what has been said above in the study of the leaf. There are furthermore some leptomatic bundles located in the pith, as mentioned above (fig. 14), but these were only found in one species, *F. castanea*. These small bundles were surrounded by a few layers of thin-walled stereome, also by a sheath, that evidently may be identical with a mestome-sheath; no inner chlorophyll-bearing sheath was observed here, since these bundles occupied an almost central position in the pith.

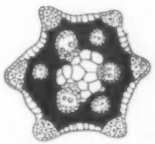

FIG. 13 — Transverse section of the stem of *F. capillaris*. × 75.

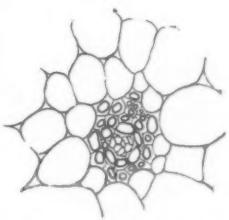

FIG. 14. A leptome-bundle, surrounded by stereome from the pith of *F. castanea*; transverse section. × 320.

The peduncle.

The anatomical structure of the peduncles, which bear the spikes, does not differ in any essential degree from that of the stem. In *F. castanea*, for instance, the peduncle is slightly compressed; the pith occupies a smaller part of the section and has no bundles neither of pure stereome or with leptome.

Tannin was found in both the bark and pith. The same reduction in the size of the pith was, also, observed in *F. laxa* and *F. autumnalis;* in the latter the stereome appeared to have become more developed than in the stem, forming larger groups and, also, by being more thick-walled.

The root.

With the exception of Van Tieghem,* Russow, De Bary and Klinge, very few authors have given account of the root-structure in the *Cyperaceæ*. The elaborate work of Klinge, to which we have often referred in our articles upon this order, contains a number of detailed descriptions, by which we are enabled to obtain a broad view of the general structure besides a comparison between the principal characteristics of the roots in *Cyperaceæ* and *Gramineæ*. The very important character to which Klinge has called attention as one of the most reliable for distinguishing roots of *Cyperaceæ* from *Gramineæ*, the tangential collapsing of the bark-cells, this character has, also, been observed by the writer in a number of genera from this country, including *Fimbristylis*. The structure of the endodermis seems, according to our own observations, to represent a number of variations. This sheath occurs in our species of *Fimbristylis* with more or less thickened cell-walls; in *F. castanea* the thickening appears to have reached the maximum, and the individual cells look as if their lumen had almost entirely disappeared. In *F. thermalis* and *F. stenophylla* the endodermis is, also, distinctly thick-walled with a number of layers representing an *O-endodermis*. And in *F. autumnalis*, which shows a rather weak mechanical structure, the endodermis is, nevertheless, somewhat thickened, sufficiently to be characterized as an *O-endodermis*. In *F. laxa* the endodermis-cells are not thickened all round, but only on the radial and inner walls in the shape of a typical U-endodermis.

In regard to the pericambium, we have only noticed this tissue as consisting of a single layer of thin-walled cells, or as in *F. castanea* of thick-walled. Otherwise the pericambium shows the same peculiarity, discussed in the works cited above, by Klinge and Van Tieghem: that it does not form a closed ring in all the *Gramineæ* and *Cyperaceæ*, but is frequently interrupted by the protohadrome. It will, however, require further observation in order to ascertain, whether this fact is common to all or only to certain genera of the *Cyperaceæ*. While Klinge has observed the protohadrome to border immediately on the endodermis, thus breaking through the

* Van Tieghem, Ph., Recherches sur la symétrie de structure des plantes vasculaires (Annales d. sc. nat., 5th series, vol. xiii, Paris, 1870–71, p 5).

pericambium, in several species of *Carex*, *Eriopharum*, *Scirpus*, *Heleocharis* and according to Duval-Jouve, also in *Cyperus globosus*, *C. fuscus*, *C. vegetus* and *C. serotinus*, Van Tieghem did not observe this to take place in *Carex brizoides*. Moreover both Duval-Jouve and Klinge observed a similar separation of the protohadrome from the endodermis in various species of *Cyperus* and *Galilea mucronata*. In *Carex Fraseri*, as we have mentioned in a previous article, the protohadrome is, also, separated from the endodermis. The innermost part of the central-cylinder is in *F. autumnalis*, *F. laxa* and *F. thermalis* occupied by a single, large vessel, and several in *F. castanea* and *F. stenophylla*. The conjunctive tissue seems most often to be thin-walled, with the exception of *F. castanea* and *F. laxa*. The structure of the roots in our species of the genus does not seem to present any other mechanical protection than that rendered by the thick-walled endodermis, although we should have expected to find a similar protection in the innermost layers of the bark corresponding to what we observed in *Scleria* and *Lipocarpha* with their thick-walled bark-parenchyma.

These anatomical details, which we have observed in North American species of *Fimbristylis*, seem to illustrate that we have only one genus before us; the species which by Torrey were referred to *Isolepis* appear to be inseparable from the others, not only from an anatomical, but, also, from a morphological viewpoint. And if we consider the various species, as we have studied them in this country, they exhibit a sufficient number of characters which may be regarded as "mutual affinities," such as these are understood in orders as large as the *Cyperaceæ*. But it does not seem possible to draw any such distinction, as for instance to separate the species into "Xerophytes or Hydrophytes," even if the local environment might suggest these plants to belong to different "plant-societies." Because the internal structure of the stem, the leaf and the root does not furnish any evidence that certain anatomical features are necessarily dependent on a special climate or soil, neither very dry nor very damp. It seems much more natural simply to acknowledge that such and such species live under such and such conditions, even if we, on the other hand, are unable to account for the similarities and diversities in structure. The statement that bog-plants may possess xerophytic characters and vice versa gives no satisfaction, and is even misleading; characters may have been simply inherited without being at present of any particular advantage to the species. The inner, chlorophyll-bearing sheath may represent a character of that kind, its function being, so far, unexplainable.

This sheath is, as we have stated above, not especially characteristic of any type of *Fimbristylis*; it is common to our native species and a number from the old world. It is not restricted either to any certain shape of leaf or to species from any peculiar region or locality. Furthermore the relative development of the mechanical tissue in our genus from dry as well as from wet soil furnishes no information regarding a supposed existence of plant-societies with xerophytic or hydrophytic structures; neither the radial arrangement of the palisade-cells or the presence of a parenchyma-sheath. Hence an attempt to classify our native species of *Fimbristylis* as "xerophytes or hydrophytes" would seem very unnatural and not in conformity with their biological peculiarities.

Brookland, D. C., December, 1898.

ART. XLIX.—*On Roscoelite;* by W. F. HILLEBRAND and H. W. TURNER, with a note on its chemical constitution by F. W. CLARKE.

ANALYSIS AND COMPOSITION, BY W. F. HILLEBRAND.

THE rare mineral roscoelite has greatly needed reëxamination in order to reconcile the discrepancies between the analyses of Roscoe and Genth and to establish a satisfactory formula for this supposed vanadium mica. To the kindness of Mr. G. W. Kimble of Placerville, Cal., I am indebted through Mr. H. W. Turner for specimens from the Stockslager mine, from which a limited amount of fairly pure material was picked out. This was then laboriously purified by the aid of Thoulet's solution, the result being a very nearly pure product weighing only 1·2 grams and having after drying at 100° C. a density of 2·97 at 20° C.

Notwithstanding the small amount, it was possible by the exercise of care to make fairly satisfactory analyses.

With regard to the methods employed little need be said except as to the determination of the condition of the vanadium. For this purpose decomposition was effected by rather dilute H_2SO_4 in sealed tubes, the greatest care being taken to expel every trace of air from the powder and acid and to seal the tube during passage of a current of CO_2. Otherwise it is impossible to prevent oxidation of a considerable part of the V_2O_3. In one case, unfortunately, the air cannot have been fully expelled, for the solution after decomposition was blue instead of green and much less oxygen was required in titration than when the color was green.

The contents of the tube, still warm, were poured into fairly hot freshly boiled water and titrated rapidly. Iron and vanadium were then reduced by H_2S gas, the latter boiled out in a current of CO_2, and titration repeated on the hot liquid. The solution was then boiled with ammonia, the precipitate fused with Na_2CO_3, leached with water, and the residue again fused with Na_2CO_3 and leached to remove the last of the vanadium. This residue was then fused with $KHSO_4$,* dissolved in dilute H_2SO_4, boiled first with H_2S and then in a current of CO_2, and the liquid titrated for total iron. The solution held titanium which was then estimated colorimetrically.

The first of the titration results gave the effect of all iron, assuming its existence as FeO, and of all vanadium that might

* Any slight trace of vanadium remaining will impart a bright yellow color to the cold $KHSO_4$ fusion, a test which proved useful more than once during the analysis.

exist in a lower state of oxidation than V_2O_5. The second gave all iron as FeO and all vanadium as V_2O_4. Deduct from both the figure for FeO and the remainder gives that for vanadium. In this way two very concordant results were obtained for total vanadium as V_2O_4 which were supplemented by tests on portions used for other constituents, but only one was obtained for the vanadium as it exists in the mineral, a second being vitiated by evident oxidation during decomposition in the tube. As a check, however, a fresh sample of unpurified mineral was similarly treated and it was found that fully nine-tenths of the vanadium existed as V_2O_3, a result confirming the single test on the purified material which showed 93·5 per cent as V_2O_3. It is not impossible that slight oxidation had taken place even in these cases, and I feel justified in assuming with Genth that the vanadium should be considered wholly as V_2O_3.

In the other portions analyzed the vanadium was likewise titrated in V_2O_4 condition, but only after separation from iron, titanium and aluminum by fusion with Na_2CO_3, extraction with water and separation of dissolved alumina by ammonium carbonate. A second fusion of the residue and of the precipitated alumina was necessary in order to extract all the vanadium. These numerous manipulations render the figures for Al_2O_3 perhaps the least trustworthy of all, but the average given is probably not far from correct.

The iron is assumed to be present as FeO; and the titanium to belong to a foreign mineral, since a test on unpurified material gave much more, namely, 1·50 per cent TiO_2, without accompanying increase in FeO, which latter observation seems to exclude ilmenite as the source of the titanium.

Both the iron and magnesium are supposed to belong to the roscoelite, since they were found by Genth in nearly the same amounts and no recognizable iron or magnesium minerals were noticed in the purified powder.

For comparison, the mean of Roscoe's analyses and that one of Genth's considered by himself to be his best are also given in the table on the following page.

Very marked differences are apparent in the three analyses by different chemists. If titanium was present in the material analyzed by Genth and Roscoe, as is very probable, their high results for alumina are in great part at least accounted for. It is inconceivable how Genth obtained his value for water by ignition, since the mineral oxidizes when heated in air. In fact the oxidation in one of my own analyses, after allowing for loss of water as ascertained by direct weight, was almost what theory requires for the oxidation of V_2O_3 to V_2O_5 and of FeO to Fe_2O_3, or 5·14 per cent instead of 5·27 per cent. It

may fairly be assumed that his water was weighed directly after expulsion by ignition of the powder. Roscoe's figures for water, if not for moisture, must be affected by error, probably arising from the unsuspected oxidation of vanadium.

ANALYSES OF ROSCOELITE.

Amount used.	Hillebrand. ·3000*g.*	·2531*g.*	·2635*g.*	·1560*g.**	·2038*g.*	Mean.	Genth.	Roscoe.	
SiO_2	45·30	45·04				45·17	47·69	SiO_2	41·25
TiO_2	·77		·77		·80	·78		V_2O_5	28·60†
V_2O_3	23·90	24·00		24·09	24·06	24·01	20·56	Al_2O_3	14·14
Al_2O_3		11·74	11·34			11·54	14·10	Fe_2O_3	1·13
FeO	1·59			1·65	1·57	1·60	1·67	Mn_2O_3	1·15
MgO	1·64					1·64	2·00	CaO	·61
K_2O		10·41	10·32			10·37	7·59	MgO	2·01
Na_2O		·13	none			·06	·17	K_2O	8·56
Li_2O		ft. tr.				ft. tr.	tr.	Na_2O	·82
H_2O below 105° C.	·40					·40		Water	1·08
								Moisture	2·27
H_2O 105–280° C.	·17		4·29			·17	4·96 ign.		101·62
H_2O above 280° C.						4·12			
Fl						none			
						99·86	98·76		

From the column of means of my own analyses the following ratios are obtainable:

SiO_2	·753
V_2O_3	·159
Al_2O_3	·113
FeO	·022
MgO	·041
K_2O	·110
H_2O	·229

The entire absence of manganese and of calcium in my own and Genth's samples tends to confirm the suspicion that Roscoe's material was far from pure. It is to be remarked, however, that my figures for vanadium agree quite closely with his and differ widely from Genth's.‡

Discrepancies of this kind are not necessarily to be ascribed to faulty analyses. It is well enough known that in any one

* 4·94 per cent oxygen used for complete oxidation instead of 5·27 needed for all V as V_2O_3 and Fe as FeO.

† Equivalent to 23·59 per cent V_2O_3.

‡ This agreement is probably more apparent than real for the reason that Roscoe's figure would be materially lowered by regarding the iron of his analysis as FeO instead of Fe_2O_3 in conformity with my analysis.

species of mica various molecules must sometimes be assumed to exist in different proportions and the general formula for such a species can only be arrived at by comparison of a series of analyses of different varieties. Hence, in view of the lack of any simple ratios, the deduction of a definite and final formula from my data is not justifiable. Further analyses are needed of new and very pure material from other locations even if these be not far removed from the source of the present material. Nevertheless, in the hands of an expert very unpromising data may often be made to afford positive indications, and that this is true in the present case the following discussion by Professor F. W. Clarke clearly shows.

CHEMICAL CONSTITUTION OF ROSCOELITE, BY F. W. CLARKE.

The ratios given in the foregoing new analysis, used directly, lead to the following empirical formula for roscoelite:

$$H_{458}K_{220}Fe_{22}Mg_{41}Al_{226}V_{218}Si_{753}O_{2724}.$$

Here H to K, and Mg to Fe are as 2 to 1. Between O and Si, however, the ratio is not simple, and lies below the orthosilicate and above the trisilicate proportion. Since in many micas the groups SiO_4 and Si_3O_8 are replaceable, that suggestion may be followed out here; and then the formula reduces to

$$R'_{679}R''_{68}Al_{226}V_{218}(SiO_4)_{536}(Si_3O_8)_{71}.$$

From this expression, applying Clarke's mica theory, the mineral may be regarded as a molecular mixture of the three compounds

1.	2.	3.
$SiO_4 = FeK$	$Si_3O_8 = KH_2$	$SiO_4 = KH_3$
$Al—SiO_4 = MgH$	$Al—Si_3O_8 = KH_2$	$Al—SiO_4 = V$
$SiO_4 = MgH,$	$Si_3O_8 = Al,$	$SiO_4 = V,$

in the ratio 21 : 22 : 159, or nearly 1 : 1 : 8. Upon reducing the analysis to 100 per cent, after throwing out the TiO_2 and the water lost below 280° as extraneous, we get the following comparison between the results found and the theoretical composition.

	Found.	Reduced.	Calculated.
SiO_2	45·17	45·88	45·52
TiO_2	·78	----	----
V_2O_3	24·01	24·39	24·64
Al_2O_3	11·54	11·73	11·62
MgO	1·64	1·66	1·72
FeO	1·60	1·63	1·55
K_2O	10·37	10·53	10·81
H_2O, 280°—	·57	----	----
" 280°+	4·12	4·18	4·14
	99·80	100·00	100·00

This comparison, based on the ratio 21 : 22 : 159, is as satisfactory as could be expected.

Of these component molecules, the first represents the normal phlogopite type: the second is a trisilicate alkaline biotite; and the third, which forms 74·5 per cent of the whole mass, is a muscovite in which two-thirds of the aluminum have been replaced by vanadium; in short, a vanadium muscovite. Ordinary muscovite is $Al_3(SiO_4)_3KH_2$; and whether a corresponding $V_3(SiO_4)_3KH_2$ exists, can be determined only by analyses of roscoelite from other localities, and so learning its range of variation. That vanadium may replace aluminum is shown by the fact that Piccini has prepared true vanadium alums. That roscoelite is essentially a vanadium muscovite seems to be fairly well established. As for the molecule $Al_2(Si_3O_8)_3K_2H_4$, its existence is indicated in some other micas; and in Simmler's "helvetan" it seems to be the dominant molecule.

The Occurrence of Roscoelite, by H. W. Turner.

According to H. G. Hanks,* at one time State mineralogist of California, attention was first called to roscoelite by Dr. James Blake at a meeting of the San Francisco Microscopical Society, July 2d, 1874. The specimens then exhibited were from the Stockslager† mine, which is about 1^{klm} southwesterly from Lotus on Granite Creek in Eldorado County.

At a meeting of the California Academy of Sciences held July 20, 1874, Dr. Blake presented specimens of the same mineral, which he then supposed to be a chromium mica.

At a meeting of the California Academy held August 2, 1875,‡ Dr. Blake read a paper on roscoelite. Samples sent by him to Dr. Genth of Philadelphia were found to contain vanadium. The mineral was named by Blake in honor of Professor Roscoe of Manchester, England, who had made vanadium a special study. Dr. Blake calls attention to the fact that Dr. Hall found vanadium widely diffused in many rocks, generally associated with phosphorus. According to Hanks the Stockslager vein from which the roscoelite obtained by Dr. Blake was taken, is small and not continuous, varying from two inches to a foot in thickness and running nearly parallel with Granite Creek. Associated with the quartz is calcite, and there are at least two varieties of iron sulphide present, probably pyrite and chalcopyrite. Hanks states further that the gold occurs only with the roscoelite and is

* Second Ann. Rep. State Mineralogist of California, pp. 263–4, 1880–2.

† According to Lindgren (see Economic Sheet of the Placerville folio of the Geol. Atlas of the U. S.) this name should be spelled as above, but Hanks spells it *Stuckslager*.

‡ Proceedings Cal. Acad., vol. vi, p. 150, 1875

found interstratified with the roscoelite laminæ in pieces from the value of one dollar to the minutest microscopic particles. He also states that from four to five hundred pounds of roscoelite were obtained by the miners, all of which was wasted in extracting the gold.

Mr. George W. Kimble of Placerville, California, for many years county surveyor, has furnished the California material analyzed by Dr. Hillebrand as well as other specimens. In these specimens the roscoelite is in part embedded in quartz and probably contemporaneous in formation with the quartz, and in part fills little cracks in the quartz and therefore somewhat later.

There are given below four localities where roscoelite has been found, according to Mr. Kimble, to whom the author is indebted for the following information about the occurrence of the mineral at these localities.

FIG. 1. Geological map copied from the Placerville folio, showing roscoelite localities. Geology by W. Lindgren.

The accompanying map, on the scale of about 1-150000, gives the exact localities where the roscoelite has been found. The Calaveras formation is largely of Carboniferous age, as may

also be the augite-porphyrite tuff associated with it. The serpentine is later than the Calaveras formation and earlier than the granodiorite, which is probably late Jurassic or early Cretaceous. It will be observed that all of the localities are at or near the contact of an intrusive granodiorite mass with the surrounding rocks, chiefly sediments and older lavas. This suggests that the mineral may be regarded as in some way due to the mineralizing solutions accompanying the intrusion of the granodiorite. However, the quartz veins clearly fill fractures which formed in the granodiorite and associated rocks after the consolidation of the granodiorite; consequently the deposition of the quartz and the associated gold and roscoelite must have been also subsequent to the consolidation of the granodiorite. The following are the localities reported by Mr. Kimble. They are all in Eldorado County, from 8 to 15$^{\text{klm}}$ northwest of Placerville.

Locality 1. Thompson Hill on its northeast slope about 2·5$^{\text{klm}}$ southeast of the Stockslager mine. — There are here fifteen or more small seams of quartz having a strike of north of west. As these seams pass through the contact of the granodiorite with the greenstone (augite-porphyrite?) they contain rich spots of gold and roscoelite. The seams of quartz pass on through the northeast point of Thompson Hill and come into the granodiorite again.

Locality 2. Stockslager mine on Granite Creek. — Mr. Lindgren informs me that the vein of the Stockslager mine is in a narrow wedge of metamorphic sediments of the Calaveras formation. Immediately east of this wedge is granodiorite, and immediately west is serpentine. Mr. Kimble states that there is here but one vein of quartz. This passes from the granodiorite into the narrow wedge of the Calaveras formation. It does not penetrate the serpentine. As previously stated, it was at this locality that by far the larger part of the roscoelite was obtained, including that analyzed by Dr. Hillebrand.

Locality 3. South slope of spur about 2·7$^{\text{klms}}$ north of the village of Lotus.—In micaceous slate, which is part of a contact metamorphic zone of the Calaveras formation. The exact locality is about 500 feet east of the contact. It has never been demonstrated, but Mr. Kimble thinks that this quartz vein extends southeast into the granodiorite.

Locality 4. Clark Mountain on its east slope at the contact of the Calaveras formation and the granodiorite.—The occurrence here is identical with that at the Stockslager mine.

According to Kimble no roscoelite has ever been found where the seams are in granodiorite, and the latter is not altered; but some has been found at the contact of the quartz with serpentine in localities 2 and 4. All of the quartz seams at localities 1, 2, and 4 dip southwest and have pockets of gold.

Prof. Hanks* states that roscoelite was also found in Sec. 31, T. 11 N. Range 10 E, two miles from the Stockslager mine. This appears to be the Thompson Hill locality of Kimble, to whom, indeed, Prof. Hanks was probably indebted for his information. Hanks states that the roscoelite was found here in the bed rock of Big Red ravine in a dark-colored micaceous rock in small seams of quartz with calcite and gold.

The roscoelite from California shows a tendency to crystallize in little rosettes, so that individual scales of any size with the same optical orientation throughout are difficult to obtain. Some scales gave with convergent light a nearly uniaxial black cross, the hyperbolas opening but slightly on rotation, indicating a small axial angle. Like all other micas it is optically negative. The pleochroism as seen in thin foils is, c and b clove brown to greenish yellow brown, a light greenish yellow. In the scales of the powder analyzed no rutile needles or other inclusions were detected, but in the center of a rosette of roscoelite scales were found dark grains with a metallic luster. These grains are of sufficient size to have fallen with the heavy minerals during the process of separation with the Thoulet solution, and it is not likely that any of them have been included in the powder analyzed, although they were noted in the impure material before it had undergone the final separation. The grains show no crystal form and were not determined.

* Loco citato, p. 263.

ART. L.—*On Gravitation in Gaseous Nebulæ*; by FRANCIS E. NIPHER.

THIS subject has received attention of late through the work of Dr. See, who has rediscovered the law announced by Ritter in 1878. According to Ritter, if R be the radius of a spherical mass of gas of cosmical dimensions, and T its temperature, the product TR = constant. As Ritter announced, the heat capacity of such a gravitating mass is negative. If heat leaves the gas, it contracts and becomes warmer. Dr. C. M. Woodward has recently published a paper* in which he deals with the conditions of equilibrium in such a mass, and he deduced the equation for the mass of the central core of a gravitating spherical nebula

$$M = \frac{2CT_0 r}{K}$$

Here C is the constant for the gas, and M is the mass internal to any radius r. K is the gravitation constant and T_0 is the constant temperature of the mass. Woodward admits that if such a mass could be contracted, its temperature would rise, but he denies that gravitation is competent to contract the gas, and even concludes that such a nebula cannot lose heat by radiation.

The present writer, in the succeeding number of the Transactions, has shown that such contraction is possible; and that when T is made variable in the above formula, the value of Ritter's constant is determined by that equation, in terms of the gravitation constant, the constant for the gas, and the mass M internal to r.

This equation is then applied to a cosmical mass of hydrogen. What must be the physical condition in order that a central mass or core, having a radius equal to that of the sun, should contain a mass equal to that of the sun. The conditions of the problem determine r, C and M; and K being known, the value of T turns out to be 20,000,000 degrees centigrade. The pressure at the surface of this sphere is computed, and it is found to be $3{\cdot}706 \times 10^{14}$ dynes per square centimeter, or 366,000,000 atmospheres. The average density of the spherical mass, which is three times the density at the surface of the hydrogen sun, is about 7 per cent less than the average density of the sun itself. The pressure at a distance of 92 million miles from the center of mass is found to be about 0·4 of an atmosphere.

* Trans. Acad. of Sci. of St. Louis, vol. ix, No. 3.

The equations show that the same pressures and densities would hold for any other perfect gas. In fact, the above equation shows that if r and M are fixed, the product TC must be constant for all gases. This carries with it the conclusion shown by the other equations, that the average density of such a solar mass is independent of the nature of the gas. This is a matter of great significance, when taken in connection with the fact that the real density of the sun is only slightly greater than the density of the hypothetical hydrogen sun.

The real condition around our sun is, that increasing opacity to radiation as one goes to levels of smaller radius, has retained the heat within the dense nucleus. The rarefied external parts of the solar nebula have parted with their heat and the temperature throughout the mass has ceased to be uniform. Interplanetary pressures have been abolished. Hydrogen would solidify at a distance of 92 million miles from our sun if away from any large mass of matter. And this obliteration of cosmical pressure has almost wholly compensated the fall in temperature of the sun from 20 millions at least to perhaps 10,000 degrees.

The fact that a gaseous mass can apparently contract itself, and heat up in some such way as it would do if it were compressed by the action of some external system, is obviously of profound significance. The clue that it seems to give concerning the nature of gravitation is well worthy of the most serious attention. Is not gravitation the action upon matter of a system wholly external to matter?

ART. LI.—*The Titration of Oxalic Acid by Potassium Permanganate in presence of Hydrochloric Acid;* by F. A. GOOCH and C. A. PETERS.

[Contributions from the Kent Chemical Laboratory of Yale University—LXXXII.]

LÖWENTHAL and LENSSEN* were the first to show that the titration of a ferrous salt by potassium permanganate in the presence of hydrochloric acid, according to the process of Margueritte† is vitiated by the evolution of chlorine outside the main reaction, and to point out that a remedy for the difficulty is to be found in the titration of the ferrous salt in divided portions, other equal volumes of the ferrous solution being added to the liquid in which the first titration is accomplished until the amount of iron indicated by successive titrations becomes constant.

Kessler‡ showed the restraining influence of certain sulphates, of manganous sulphate in particular, upon the irregular and undesirable interaction of the permanganate and hydrochloric acid, and Zimmermann,§ in apparent ignorance of Kessler's forgotten proposal, advocated the introduction of a manganous salt, best the sulphate, into the ferrous salt to be determined, thus accomplishing the purpose of the empirical procedure of Löwenthal and Lenssen.

The tendency toward evolution of chlorine in the oxidation of a ferrous salt by permanganate, as compared with the absence of such tendency in the similar oxidation of oxalic acid, in presence of hydrochloric acid, was explained by Zimmermann on the hypothesis that an oxide of iron higher than ferric oxide is formed as an intermediate product, and that this unstable oxide is sufficiently active to break up hydrochloric acid as well as to oxidize more of the ferrous salt. Quite recently, Wagner‖ finds explanation of the sensitiveness of the hydrochloric acid solution of the ferrous salt in the probable formation of chlor-ferrous acid (analogous to chlorplatinic and chlor-auric acids), which suffers oxidation more readily than hydrochloric acid under the action of the permanganate. The protective influence of the manganous salt turns apparently, as Zimmermann suggested, upon the initiation of Guyard's reaction, according to which the permanganate and manganous salt interact to form a higher oxide of manganese of a constitution approaching the dioxide more or less closely—this oxide being capable of oxidizing the ferrous salt, but slow

* Zeit. f. Anal. Chem., i, 329. † Ann. d. Chim. et d. Phys. [3], xviii, 244.
‡ Ann. d. Phys. u. Chem., cxviii, 48; cxix, 225–226.
§ Ann. d. Chem., ccxiii, 302.
‖ Maasanalytische Studien, Habilitationsschrift, Leipzic, 1898.

to act upon the hydrochloric acid, or the chlor-ferrous acid of Wagner. According to Volhard* the reaction of Guyard is favored and hastened by heat and concentration of the solution, while it is delayed by acidity and dilution; but even in solutions containing very little manganous salt and a considerable quantity of free acid the faint rose color developed by the careful addition of permanganate ultimately vanishes until every trace of the manganous salt is precipitated. When a considerable amount of the salt is present interaction follows immediately the introduction of the permanganate. Zimmermann advocates the use of 4 grams of manganous sulphate uniformly in titrations of a ferrous salt by permanganate, a procedure to which Wagner gives acquiescence, though pointing out that a ninth of that amount is all that he finds to be necessary. The excess of the manganous salt can do no harm so long as the higher oxide, the product of interaction of the manganous salt and the permanganate, is immediately reduced by even traces of a ferrous salt, and this appears to be the case at least within the limits proposed by Zimmermann and Wagner. Thus we find, as shown in results of the accompanying table, that so much as five grams of the sulphate may be present in 135$^{cm^3}$ of the liquid, containing about 5$^{cm^3}$ of hydrochloric acid of full strength, without interfering with the regularity of the titration; and the effect is trivial even when the amount of manganous sulphate reaches ten grams. We find also practical regularity of working when manganous chloride is substituted for the sulphate, and in this respect our results accord with those of Zimmermann and differ from those of Wagner.†

Total volume at beginning of titration. cm^3.	HCl Sp. gr. 1·09. cm^3.	$FeCl_2$. cm^3.	$KMnO_4$ $\frac{1}{10}$ N. cm^3.	$MnSO_4 . 5H_2O$. grams.	$MnCl_2 . 4H_2O$. grams.
135	10	25	21·70	1·	----
135	10	25	21·70	3·	----
135	10	25	21·70	5·	----
135	10	25	21·75	7·	----
135	10	25	21·75	10·	----
145	20	25	21·75	10·	----
175	50	25	21·75	10·	----
135	10	25	21·70	----	1·
135	10	25	21·70	----	2·
145	20	25	21·70	----	2·
155	30	25	21·75	----	3·
165	40	25	21·70	----	4·

In all cases, however, in which the larger amounts of manganous salt are present, the end reaction is marked by the advent

* Ann. d. Chem., cxcviii, 318, 1879. † Loc. cit., p. 104.

of a brownish-red precipitate rather than the clear pink of the soluble permanganate, and it is obvious that in case the solutions to be oxidized were not active enough to act with rapidity upon the product of the Guyard reaction, difficulty might follow the failure to adjust the conditions more particularly.

It has been stated by Fleischer* and Zimmermann† that hydrochloric acid interferes in no way with the titration of oxalic acid by potassium permanganate. This statement, however, is not in accord with our experience; for we find that in such titrations there is a small though real waste of permanganate proportionate to the amount of hydrochloric acid present. This fact is brought out clearly in the comparison of experiments of section A in the following table, in which no hydrochloric acid was present, with experiments B, in which hydrochloric acid was present.

Temperature at beginning about 80° C.

Approximate volume at beginning of titration.	H_2SO_4 1 : 1 cm³.	HCl Sp. gr. 1·09. cm³.	Ammonium oxalate $\frac{1}{15}$ N. cm³.	$KMnO_4$. cm³	Variation from mean of A taken as standard. cm³.
			A		
200	5	....	50	47·50	0·00
200	5	....	50	47·50	0·00
200	10	....	50	47·50	0·00
200	10	....	50	47·50	0·00
200	25	....	50	47·50	0·00
200	25	....	50	47·50	0·00
			B		
150	10	2·5	25	23·80	+0·05
150	10	2·5	25	23·90	+0·15
150	10	5·0	25	23·90	+0·15
150	10	10·0	25	24·00	+0·25
500	5	....	25	23·80	+0·05
500	10	10·0	25	24·00	+0·25
500	10	10·0	25	24·10	+0·35

From these results it is evident that, though the error introduced by the presence of the hydrochloric acid during the action of the permanganate upon the oxalic acid is small, it is plainly appreciable. The questions arise, therefore, first, as to whether the secondary action of the permanganate upon the hydrochloric acid may be prevented by the presence of a suitable amount of a manganous salt, and, secondly, as to whether in this event the reducing agent,—the oxalic acid—is sufficiently active, like the ferrous salt, to prevent the premature establishment of an end color due to the Guyard reaction. The latter question must naturally be settled before the former can

* Volumetric Analysis; Trans. by Muir, p. 71. † Loc. cit.

be taken up. In the accompanying table are recorded the effects of varying amounts of manganous salt in presence of different amounts of sulphuric acid in the reaction of permanganate upon oxalic acid.

Temperature at beginning about 80° C.

Volume at beginning. cm^3.	H_2SO_4 1 : 1. cm^3.	Ammonium oxalate. $\frac{1}{10}n$ cm^3.	$MnSO_4.5H_2O$. grams.	$KMnO_4$. cm^3.	Variation from standard.
130	5	25	----	23·75	0·00
130	5	25	0·0008	23·75	0·00
130	5	25	0·0032	23·75	0·00
130	5	25	0·0160	23·75	0·00
130	5	25	1·	23·70	−0·05
130	5	25	2·	23·75	0·00
130	5	25	2·5	23·60	−0·15
130	5	25	3·0	23·40	−0·25
130	5	25	4·0	23·60	−0·15
500	5	25	----	23·80	+0·05
500	5	25	0·0008	23·80	+0·05
500	5	25	0·0032	23·80	+0·05
500	5	25	1·	23·70	−0·05
500	5	25	2·	23·40	−0·35
500	5	25	3·	23·50	−0·25
500	5	25	4·	23·30	−0·45
130	10	25	1·	23·80	+0·05
130	10	25	2·	23·75	0·00
130	10	25	3·	23·65	−0·10
130	10	25	4·	23·50	−0·25
130	15	25	2·	23·75	0·00
130	15	25	4·	23·70	−0·05
130	15	25	5·	23·50	−0·25
130	30	25	2·	23·75	0·00
130	30	25	4·	23·70	−0·05
130	30	25	5·	23·75	0·00

From the results given it is evident that the persistence of the Guyard reaction is liable to interfere with the end reaction of oxidation of oxalic acid unless an adjustment is made between the quantity of the manganous salt, the amount of acid, and the dilution. In hot solutions of a total volume of 130^{cm^3} at the beginning, no more than 2 grams of the manganous sulphate should accompany 5 to 10^{cm^3} of the 1 : 1 sulphuric acid; when the total volume at the beginning reaches 500^{cm^3}, no more than a single gram of the salt should be present with 5^{cm^3} of the 1 : 1 sulphuric acid. The amount of manganous salt may, however, be increased considerably if the quantity of acid is increased.

As Kessler has noted, a sufficiency of the manganous salt, acting no doubt as the medium of transfer of oxygen, may bring about interaction between the permanganate and the oxalic acid at atmospheric temperatures without the tedious delay ordinarily encountered in the attempt to consummate that action in cold solutions. It would seem natural that the manganic hydroxide formed in the Guyard reaction at low temperatures should yield more readily to the reducing action of the oxalic acid than the more anhydrous form to be expected in hot solutions, so that at such temperatures the limits as to proportions of manganous salt, acid, and dilution, within which favorable action may take place, should be wider; moreover, the undesirable action of the permanganate upon hydrochloric acid, when that acid is present, should be less appreciable at lower temperatures. In our experiments, therefore, upon the oxidation of oxalic acid by potassium permanganate in presence of hydrochloric acid, we have studied the effect of varying the proportions of the manganous salt both at atmospheric temperatures and the higher temperatures generally employed.

Temperature 20°–26° C.

Number of experiment.	Volume at beginning of titration.	H_2SO_4 1 : 1 cm^3.	HCl Sp. gr. 1·09. cm^3.	Ammonium oxalate $\frac{1}{10}$ N. cm^3.	$KMnO_4$. cm^3.	$MnSO_4 . 5H_2O$. grams.	$MnCl_2 . 4H_2O$. grams.	Variation from standard. cm^3.
1	130	----	10	25	23·90	·0040	----	+0·15
2	130	----	10	25	23·90	·0120	----	+0·15
3	130	----	10	25	23·80	·0250	----	+0·05
4	130	----	10	25	23·75	·0400	----	+0·00
5	130	----	10	25	23·76	·0500	----	+0·01
6	130	----	10	25	23·70	·1000	----	−0·05
7	130	----	10	25	23·75	·2000	----	0·00
8	130	----	10	25	24·20	----	·0200	+0·45
9	130	----	10	25	23·95	----	·0200	+0·20
10	130	----	10	25	23·80	----	·0400	+0·05
11	130	----	20	25	23·75	----	·0400	0·00
12	130	----	30	25	23·75	----	·0400	0·00
13	130	----	10	25	23·75	1·0000	----	0·00
14	130	----	10	25	23·75	2·0000	----	0·00
15	130	----	10	25	23·75	3·0000	----	0·00
16	130	1	----	25	23·72	----	1·0000	−0·03
17	130	1	----	25	23·74	----	2·0000	−0·01
18	130	1	----	25	23·72	----	3·0000	−0·03
19	130	2	----	25	23·70	----	0·5000	−0·05
20	130	3	----	25	23·75	----	0·5000	0·00
			Temperature about 80°.					
21	145	10	10	25	23·90	0·5000	----	+0·15
22	145	10	10	25	23·70	1·0000	----	−0·05
23	500	10	10	25	23·75	1·0000	----	0·00
24	500	----	10	25	23·70	1·0000	----	−0·05
25	500	----	10	25	24·10	0·5000	----	+0·35

From these results it appears that the presence of a suitable amount of manganous salt—either the sulphate (exps. 4–7, 13–15, 22–24) or the chloride (exps. 10–12, 16–20)—is capable, either in cold solution (exps. 1–20) or in hot solution (exps. 22–24) of preventing the action of the permanganate upon the hydrochloric acid. It appears, also, that, for a given dilution and strength of acid, less manganous salt is needed in the cold solution (exps. 4–7) than in the hot solutions (exps. 22–24). Thus, in the hot solution, at a dilution of 145$^{cm^3}$ to 500$^{cm^3}$ 1 grm. of manganous sulphate must be present with 5$^{cm^3}$ of strong hydrochloric acid, with or without sulphuric acid; while in the cold solution 0·04 grm. of either the sulphate or chloride is enough to secure adequate protective effect. Experience showed, however, that 0·5 grm. or 1·0 grm. of the manganous salt should be present in order to push the reaction with reasonable speed in cold solutions.

Wagner* has made record of the increased evolution of chlorine in oxidations of ferrous chloride by potassium permanganate in presence of various salts, of which barium chloride was the most active. We have made some experiments, therefore, to determine whether such action would appear in the oxidation of oxalic acid in cold solutions containing certain salts, and, if so, whether it would be preventable by the presence of the manganous salt under our conditions of working. From the results given in the accompanying table, it is plain that the evolution of chlorine in cold solutions is less in the presence of these salts than when hydrochloric acid is used without them, and that such evolution may be entirely prevented (within the proportions of our work) by the presence of 0·5 grm. to 1 grm. of manganous chloride.

Finally, it appears as the result of an investigation, that the titration of oxalic acid by potassium permanganate in presence of hydrochloric acid is ordinarily attended with some inaccuracy due to liberation of chlorine from the hydrochloric acid; that this tendency may be overcome by the presence of a manganous salt—either the sulphate or chloride; that 1 grm. of the manganous salt is enough to so affect the conditions of equilibrium that titrations in moderate volumes (100$^{cm^3}$ to 500$^{cm^3}$) and in presence of hydrochloric acid (5$^{cm^3}$ to 15$^{cm^3}$ of the strong acid) may be conducted with safety and reasonable rapidity, either with or without sulphuric acid, at the ordinary atmospheric temperature.

* Loc. cit.

VOLUME AT BEGINNING OF TITRATION = 140$^{cm^3}$.
Temperature = 20°–24° C.

Ammonium oxalate. cm^3.	HCl . strongest cm^3.	$MnCl_2 . 4H_2O$.	$BaCl_2$. grams	$SrCl_2$. grams.	$CaCl_2$. grams.	$MgCl_2$. grams.	$KMnO_4$ used. cm^3.	Error. cm^3.
25	5	0·5	--	--	--	--	26·05	0·00
25	5	--	--	--	--	--	27·45	+1·40
25	5	--	2	--	--	--	26·50	+0·45
25	5	--	--	2	--	--	26·53	+0·48
25	5	--	--	--	2	--	26·36	+0·35
25	5	--	--	--	--	2	26·13	+0·08
25	5	0·5	2	--	--	--	26·05	0·00
25	5	0·5	--	2	--	--	26·10	+0·05
25	5	0·5	--	--	2	--	26·10	+0·05
25	5	0·5	--	--	--	2	26·05	0·00
25	10	1·0	2	--	--	--	26·10	+0·05
25	10	1·0	--	2	--	--	26·05	0·00
25	10	1·0	--	--	2	--	26 06	+0·01
25	10	1·0	--	--	--	2	26·11	+0·06

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Influence of Electric Oscillations on Vapors.*—It has been pointed out by Kauffman that when the vapors of various chemical compounds are subjected to the influence of electric oscillatory discharges the results obtained are: (1) the vapor becomes luminous, (2) it is crossed by spark discharges, generally of a green color, or (3) it remains dark, at least until a very high pressure is reached. More than fifty vapors were examined in this way, and the results, while too few to permit of general deductions, yet appear to indicate certain constitutive influences. Thus, for example, the aromatic amines for the most part become luminous and show quite similar appearances, the facility with which luminosity occurs appearing to be partly dependent on the basic character of the amine; since compounds which have lost their basic character by substitution, such as nitraniline and tribromaniline, no longer become luminous by the discharge. Cyclic compounds, however, containing nitrogen, do not appear to follow this rule. In the case of hydrocarbons, aliphatic compounds and the more simple benzene compounds remain dark until a very high pressure is reached, though most of the hydrocarbons containing two or more benzene rings readily become luminous. During luminosity, it was noticed that in all cases the vapor acted as a conductor.—*Zeitschr. phys. Chem.*, xxvi, 719–727, August, 1898. G. F. B.

2. *On the Occlusion of Oxygen and Hydrogen by Platinum black.*—In experiments made by Mond, Ramsay and Shields to test the occlusion of oxygen and hydrogen in this way, the platinum black was saturated with hydrogen, heated at 184° under reduced pressure, then placed in an ice calorimeter and allowed to reabsorb the gas. It was found that 68·8 calories were evolved for every gram of hydrogen occluded. In the opinion of the authors the argument offered by Berthelot in support of the existence of the compounds $Pt_{30}H_2$ and $Pt_{30}H_3$ are not justified by the facts. Moreover they conclude that the difference between palladium and platinum, in their behavior towards hydrogen, as stated by Favre, is due simply to the presence of oxygen in the platinum black. On attempting to remove the oxygen from platinum black, in order to determine its heat of occlusion, it was noticed that reducing agents, while eliminating the oxygen, were themselves occluded and retained obstinately. It was also observed that hydrogen does not remove all the oxygen, but only replaces that at first removed, both gases being simultaneously occluded. On saturating platinum black with hydrogen and exhausting it at 184°, it was found that, on allowing it to come in contact with small quantities of oxygen, the addition of more oxygen beyond a certain point, caused the pressure to increase.

On adding oxygen, however, up to atmospheric pressure, a further small quantity of the gas was absorbed and the heat simultaneously developed represented the true heat of occlusion of this quantity of oxygen. The results obtained were in close agreement with others obtained indirectly, giving as a mean 11 calories for every gram of oxygen occluded. This value agrees well with that given by Thomsen for the heat of formation of platinous hydroxide. Possibly, therefore, the two phenomena may be identical, the water required being present in platinum black dried in a vacuum.

In a subsequent investigation, the authors studied the action of palladium black in occluding gases. Prepared in the same way as platinum black, it contains 1·65 per cent or 138 times its volume of oxygen. But this oxygen, unlike that in platinum black, cannot be removed by heating to dull redness in a vacuum, but must be heated in a current of hydrogen. When heated in oxygen the palladium black absorbs it, up to a red heat, yielding a brownish black substance, which does not lose its oxygen on heating to redness in a vacuum. Nearly 1000 volumes are absorbed, an amount about three-fourths of that required to form the oxide PdO. Over 1000 volumes of hydrogen are absorbed by palladium black, though only 873 volumes are occluded, the rest having formed water with the oxygen present. About 92 per cent is removed by the air pump at the ordinary temperature, the rest at 444°. The palladium sponge from this experiment occluded 852 volumes of hydrogen, of which 98 per cent was extracted in a vacuum at ordinary temperatures. The heat of occlusion for hydrogen was found to be 46·4 calories for each gram of the gas; or 43·7 if the work of the atmosphere be allowed for. The heat developed per gram of oxygen occluded, determined indirectly, was found to be 11·2 calories, a value intermediate between that found by Thomsen for the heat of formation of palladious and palladic hydroxides; favoring the idea that this occlusion of oxygen is a true oxidation. The atomic ratio of palladium to hydrogen in the fully charged metal varies between 1·37 and 1·47; agreeing closely with the formula Pd_3H_2 as suggested by Dewar. —*Proc. Roy. Soc.*, lxii, 50–52, 290–293; *J. Chem. Soc.*, lxxiv, ii, 599, 600, December, 1898. G. F. B.

3. *On certain Derivatives of Acetylene.*—It has been observed by Erdman and Köthner that when acetylene is passed over finely divided copper heated to 400°–500° it is decomposed into hydrogen and carbon, the latter appearing in the graphitic condition. At temperatures below 250°, however, the copper unites with the gas, forming a yellowish-brown compound which is not explosive. This new substance may be more readily prepared by heating finely divided cuprous oxide in a current of acetylene at 250°. It is very bulky, and has the composition $C_{44}H_{64}Cu_8$. When heated with zinc dust in excess it yields 20 per cent of an oil having an odor like Caucasian naphtha and boiling between 190° and 250°. Well-defined acetylides of the alkali metals are

not easy to prepare. Rubidium, though acted on by acetylene at low temperatures, gives rise to no definite product. Zinc and mercury are scarcely acted on, and iron, like copper, acts catalytically, inducing condensation to oily hydrocarbons. Acetylene produces no precipitate in solutions of thallium, lead, cadmium, iron, nickel, cobalt, platinum, iridium, and rhodium. Gold chloride gives a black precipitate, changing to metallic gold on warming. Palladium chloride gives a brown precipitate soluble in ammonia. Copper acetate yields a brownish-red and silver nitrate a white precipitate. By saturating a hot solution of mercuric nitrate with acetylene, mercurocarbide nitrate $HgC : CHg . HgNO_3 . H_2O$ separates in small white crystals. It yields acetaldehyde on treatment with dilute acids.—*Zeitschr. anorg. Chem.*, xviii, 48–58, 1898.

G. F. B.

4. *On Eutropic Series of the Calcium Group.*—In 1896 Linck proposed the term catameric eutropy or more briefly eutropy, for those special cases of isomorphism in which the geometrical and physical characters of members of a series increase or decrease regularly with increase of the atomic mass of the varying element; as is the case for example in the potassium, rubidium and cæsium compounds described by Tutton. Subsequently he called attention to the fact that the quotients obtained by dividing the crystal volumes of the different members of such a series by their molecular volumes are in the ratio of simple natural numbers.

These relations have been recently tested by Eppler, who finds that they both hold good in the calcium-barium-strontium group, with one or two exceptions, as in the case of the three anhydrous sulphates, anhydrite, celestite and barite. In his paper he has brought together and compared numerous data concerning the crystallized compounds of this series of elements, giving new geometrical, optical and density determinations. In the case of cubic crystals the volume is unity and the above mentioned quotient is inversely proportional to the molecular volume. In the cubic oxides, fluorides, chlorides and nitrates of calcium, strontium and barium, the ratios are 11 : 15 : 19, 14 : 17 : 20, 18 : 19 : 20, and 20 : 21 : 22 respectively; thus decreasing with the increase in molecular mass. Although lead compounds are frequently isomorphous with those of calcium, strontium and barium, they do not belong to the same eutropic series, the physical constants falling between those of calcium and strontium or before or after those of the barium salt corresponding.—*Zeitschr. Kryst. Min.*, xxx, 118–175; *J. Chem. Soc.*, lxxiv, 560, December, 1898.

G. F. B.

5. *The distribution of Vanadium.*—It was shown by Hasselberg in 1897 (Astrophys. Jour., vi), that the mineral rutile contains vanadium in small but varying amount. He has now (ibid., ix, 143) continued his investigation to a considerable number of meteoric stones, and concludes from this that vanadium is always present in them, although it has not been detected in meteoric irons. A recent paper by Hillebrand (this Journal, vi, 209) has

shown that both vanadium and molybdenum are widely distributed in rocks, the former probably present in the silicates of the amphibole or pyroxene group and in the biotites.

6. *Determination of time of vibration of very high notes.*— F. MELDE reviews the various methods that have been suggested and used for such determinations and divides them into two groups: A, the subjective; B, the objective. Under A fall the determinations carried out by the human ear, such as the comparison of sounds, one of which is used as a standard. Determinations of notes of 6144 vibrations have been made by this method; for higher notes the method becomes inapplicable. To the subjective method also belongs the difference-tone method, which consists in measuring a third tone by the use of two primary tones. Notes of 8692 vibrations have thus been measured. To the objective method belong the various graphical and photographic methods. In conclusion the author points out the applicability of sensitive flames for the measurement of high notes.— *Wied. Ann.*, No. 4, 1899, pp. 781–793. J. T.

7. *Heat conductivity of different kinds of glass.*—A great number of determinations have been made by Focke and by Paalhorn of the thermal conductivity of glass which differ greatly in value. A. WINKELMANN endeavors to reconcile the results and concludes that it cannot be decided which determinations are the better. The discrepancies are in part due to the different ranges of temperature employed. The author concludes that it is desirable to investigate further the dependence of the conductivity of glass upon temperature.— *Wied. Ann.*, No. 4, 1899, pp. 794–802. J. T.

8. *Absorption of Electric Waves by different substances.*—The recent experiments in wireless telegraphy have excited interest in the question of the electrical opacity of non-metallic substances. E. BRANLY and G. LEBON have undertaken a research upon this question. A coherer together with a battery and a bell were placed in a cavity in the substance which was to be investigated. The substances employed were stones, blocks of cement, and boxes of sand. The electric waves were excited by a Rhigi oscillator placed outside the substance. It was found that the opacity depends upon the nature of the substance. The transparency is very great in the case of sand and the kind of building stone employed. It was extremely feeble with Portland cement. The opacity increases with the thickness. Humidity clearly increases the opacity.— *Comptes Rendus*, April 14, 1899, pp. 879–882. J. T.

9. *Radiations of Uranium.*—H. BECQUEREL concludes further study of these radiations by the following conclusions: The radiation of radio-active bodies approaches approximately in character to X-rays more nearly than to ordinary light. The most singular fact connected with these radiations is the spontaneous emission of such radiations without known cause. If it could be shown that this radiation occurs without the consump-

tion of energy, one could compare the state of uranium to that of a magnet. We can also compare the state of uranium to that of phosphorescent bodies which seem to conserve their state of phosphorescence indefinitely. The photographic and phosphorescent effect, however, of the uranium radiation indicates a consumption of energy. This consumption is extremely feeble, and seems to indicate that uranium can emit its unknown radiation for a long period of years apparently without sensible diminution.—*Comptes Rendus*, March 27, 1899, pp. 771–776. J. T.

10. *Source of Uranium Radiations.*—Prof. W. CROOKES suggests that uranium, thorium, polonium and radium have the power of separating rapidly moving molecules from slowly moving ones and appropriating a portion of the energy of the former. This energy may be used in dissociation and maintaining radiations in the ether. The air in the neighborhood of such substances would be cooled. This cooling is so small as to escape detection, and therefore the energy appears to be created out of nothing. The author computes that air contained in a room $4 \times 8 \times 7$m. could supply one h.p. for fifteen hours.—*Comptes Rendus*, 128, pp. 176–178, 1899. J. T.

11. *Phosphorescence at low Temperatures.*—A. and L. LUMIÈRE have found that the phosphorescence of calcium and zinc sulphides produced by exposure to an arc light disappears wholly at about —50° C. When exposed to a magnesium light it disappeared between —70° and —90°. When the exposure to a magnesium light is made at —191° C. the temperature of liquid air and the body is heated, phosphorescence begins to appear at —180° C. and increases with the heating. Röntgen rays act like ordinary light.—*Comptes Rendus*, 129, pp. 549–552, 1899. J. T.

12. *Recueil Données numériques publié par la Société Française de Physique. Optique par* H. DUFET. Deuxième fascicule. Propriétés optiques des solides; pp. 417–785, Paris, 1899 (Gauthier-Villars).—This volume contains tables of physical constants in the department of optics, prepared under the direction of the Physical Society of France. The opening tables give the refractive indices for different wave-lengths of certain remarkable substances, as calcite, quartz, fluorite, halite, and so on. Then follows a table of refractive indices for certain important samples of glass. After this we have an alphabetical list of inorganic solids, largely mineral species, with their optical properties arranged in tabular form; references are given to the original publication where the facts were given. This portion covers pages 466 to 632. A like table for organic solids follows, and then other tables giving the influence of temperature on optical properties, and allied subjects, close the volume. This enumeration of its contents will show how much this valuable book of reference contains.

II. Miscellaneous Scientific Intelligence.

1. *Icthyologia Ohiensis by C. S. Rafinesque, a verbatim reprint;* by R. E. Call. 8vo, 175 pp. Cleveland, 1899. (The Burrows Brothers Co.)—Rafinesque's genera and species, whether based on actually existing forms or Audubon's cruel jokes, or in later life evolved from his own diseased mind, have been a stumbling block to the systematic zoologist for more than half a century. The extreme rarity of many of his published works has increased the difficulty of recognizing the forms he described and has doubtless often forced subsequent authors to ignore him unwillingly. The late G. W. Tryon many years ago republished Rafinesque's conchological works, and now Dr. Call and his publishers give us the work on American fishes in this handsome volume, issued in a limited edition of 250 numbered copies. The volume contains a brief biographical sketch of Rafinesque, an account of his ichthyological work, a verbatim reprint of the Ichthyologica Ohiensis (of which only eight copies are now known to exist), a bibliography of his papers on fishes, and a reproduction of a previously unpublished letter from Rafinesque to Dr. Daniel Drake of Cincinnati, containing a sketch of one of the fishes described. It seems ungrateful to criticise a work of this kind for its omissions, but a general index is much needed, the reprint of the original index of the Icthyologica with references to the genera and English names being almost useless for reference.

If the "excentric naturalist" could have foreseen the appearance, before the end of the century, of this luxurious volume devoted to a reprint of the work to which he gave himself with such prodigality of unrewarded zeal, he might have forgiven and forgotten the neglect and scorn of his cotemporaries and retained his reason through the unhappy later years of his life. S. I. S.

2. *Elementary Physiology;* by Benjamin Moore, M.A. pp. 295. New York, 1899. (Longmans, Green & Co.)—This elementary text-book differs in several respects from many other books of its class. First, a relatively large portion of the text is devoted to the description of the structure of the animal body. Since the functions of the organism are so closely connected with its morphological characters, a somewhat comprehensive survey of the latter becomes highly essential to a well-conducted course in physiology for beginners. The usefulness of the present text-book is greatly increased by an unusually large number of well-selected illustrations. Second, in the consideration of the various departments of physiology due appreciation of the relative importance of the phenomena discussed has usually been shown. Too many of the elementary text-books are unsatisfactory in this respect: they either unduly emphasize certain actions of the body, or omit entirely chapters which do not permit of easy treatment. Professor Moore's little book certainly does not err in the latter respect, and it may even be questioned whether occasional topics

have not been introduced with too great detail for the beginner. Third, the reader is not allowed to forget that physiology is an experimental science and should properly be taught as such; accordingly, the general method of the book tends to encourage observation and experiment. A series of carefully defined exercises forms a useful appendix. L. B. M.

3. *Experimental Morphology, Part II;* by C. B. DAVENPORT. New York, 1899.—In this second installment of his valuable treatise Dr. Davenport considers the effects of chemical and physical agents on growth. Plants lend themselves so readily to observations respecting growth, that they have received from Dr. Davenport a degree of attention in this work which compels the student of plant physiology to accept his aid. The literature of the whole province has been carefully examined, and few omissions can be noted in the references. On the whole, the editorial work has been wonderfully well done, and the errors are so few that they need not be mentioned here; they do not appear likely to mislead seriously any students who make use of the vast amount of material which has been gathered patiently, and for the most part has been well arranged. The botanical phases of experimental morphology are at present attracting a large number of enthusiastic students who are moved to consider questions in a broad way, and are stimulated by just such books as Dr. Davenport's, to ask some of these questions, at first hand, of nature. G. L. G.

4. *Recherche, Captage et Aménagement des Sources Thermo-Minérales.* Origine des eaux Thermo-Minérales; Géologie; Propriétés physiques et chimiques. By L. DE LAUNAY, pp. x, 635, large 8vo. Paris, 1899 (Librairie Polytechnique Baudry et Cie., éditeurs).—M. De Launay has added another to the series of highly valuable practical works prepared by him. The previous volumes on Mineral Deposits, on the Gold Mines of Transvaal, and the Diamonds of South Africa, have been noticed in earlier numbers of this Journal. The present volume discusses thermal springs in different parts of the world. The treatment is thorough and exhaustive. The origin of the springs and their relation to geological and topographical features is first taken up. Then comes a discussion of their chemical composition with the salts and gas in solution, accompanied by numerous analytical tables. Following these are data in regard to the temperature at different springs, ranging, for example, from 81°·5 at Chaudes-Aigues (Cantal) to 27° at Uriage (Isère). The latter half of the work goes more minutely into the account of the individual localities in different parts of the world, giving a large amount of very interesting information about a multitude of places. The work closes with details in regard to the distribution of the hot water to the different establishments, with numerous excellent illustrations.

OBITUARY.

Dr. FRANZ RITTER VON HAUER, the distinguished Austrian geologist, died March 20th, at the age of seventy-seven years.

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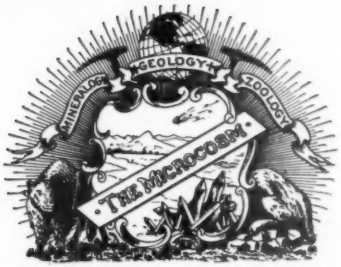

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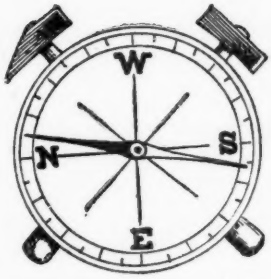

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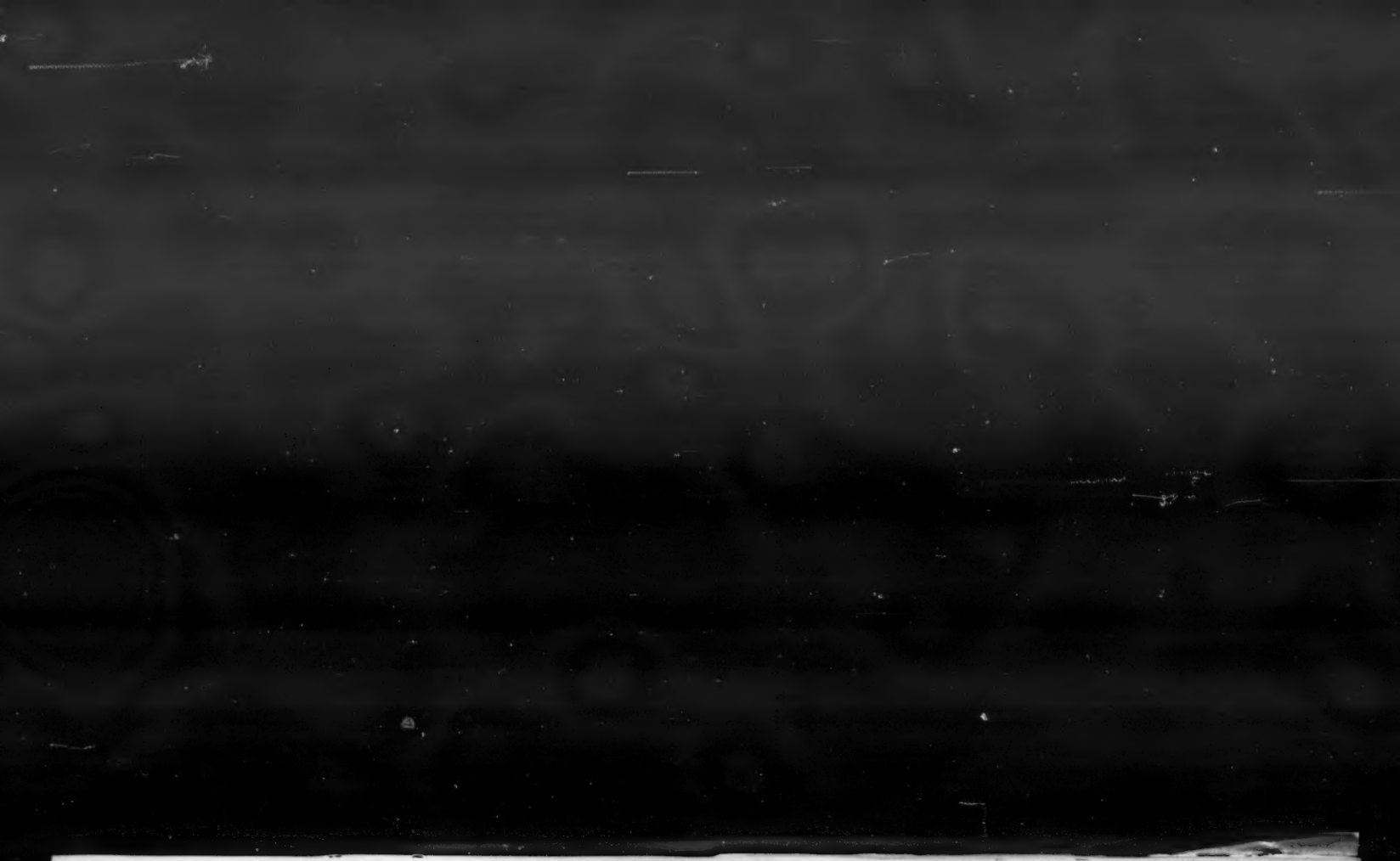
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